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WORD-PICTURE RELATIONSHIPS IN AUDIOVISUAL PRESENTATIONS.
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THE MERITS OF VISUAL AND AUDITORY STIMULI AT EACH STAGE OF THE LEARNING PROCESS WERE PRESENTED IN THIS WORKING PAPER. SPECIAL ATTENTION WAS GIVEN TO THE DIFFERENCES IN RESPONSES REQUIRED AT EACH STAGE AND THEIR CONTROL BY THE NATURE OF THE LEARNING TASK. THE PROBLEM WAS APPROACHED BY A CONSIDERATION OF THE BASIC PROPERTIES OF WORDS AND PICTURES AND AN ANALYSIS OF THE RESPONSES REQUIRED FOR LEARNING. A REVIEW OF EXPERIMENTS AND LITERATURE SHOWED A LACK OF RELEVANT EXPERIMENTAL DATA. THIS ANALYSIS ACCOUNTED FOR FOUR SETS OF VARIABLES -- STIMULUS, RESPONSE, TASK, AND AUDIENCE. THE SPECIFICATION OF THE SEQUENCE OF RESPONSES WAS DETERMINED BY THE NATURE OF THE LEARNING TASK, AND MOTIVATED, CUED, AND REINFORCED BY STIMULUS VARIABLES, AUDIENCE VARIABLES DETERMINED THE ABILITY TO MAKE THE REQUIRED RESPONSES TO THE STIMULI, WHICH WERE GENERAL INTELLIGENCE, SPECIAL APTITUDES, AND PREVIOUSLY ACQUIRED KNOWLEDGE. THE ANALYSIS SHOWED THE ASSESSMENT PROBLEMS OF VISUAL, AUDITORY, AND AUDIOVISUAL STIMULI. MORE LABORATORY EXPERIMENTS WERE SUGGESTED TO EXPLORE THE RELATIONSHIPS OF SENSORY DOMINANCE LEARNING AND RETENTION. (RS)

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AUDIO-VISUAL PRESENTATIONS

(A working paper)

Mark A. May

U. S. Department of Health, Education and Welfare - Office of Education Contract No. OE-5-16-006.

July 20, 1965

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WORD-PICTURE RELATIONSHIPS
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Part I - Introduction

1. Nature of the Problem

In a previous paper on "Enhancements and Simplifications Of Stimulus Variables in A-V Presentations," audio-visual elements were considered from the standpoint of the functions they perform for motivating, cueing, reinforcing, and simplifying the responses that are required for learning. Four main categories of responses were identified; (a) paying attention, (b) identifying and focusing attention on the relevant cues, (c) responding to the relevant cues in a manner required by the learning task, and (d) fixating these responses so they will be retained and can be utilized. These four categories correspond roughly to stages in the process of learning from A-V presentations.

The experimental literature was reviewed, and stimulus variables were organized under the headings of Motivators, Reinforcers, Cue Identifiers, and Simplifiers. The relative merits of the visual and auditory components for the performance of these functions, at each stage in the learning process, were not considered. In the present paper the steps in the learning process are presented in more detail.

The roles of visual and auditory stimuli for motivating and cueing the response required, at each stage, are discussed. In the previous paper the main problem was to discover the kinds of devices and procedures that are most effective for motivating, cueing, reinforcing and simplifying the responses involved in the total learning process. In this paper special attention is given not only to differences in responses required at each stage, but also to how they are controlled by the nature of the learning task. The responses required at each stage may be different for different tasks. At some stages and for some tasks visuals may be better than aurals, and audio-visuals may be even better. In order, therefore, to design experiments for testing the relative effectiveness of visual, auditory, and audio-visual stimuli, it is essential to consider the many ways in which they can be varied.

The nonverbal visual components of a presentation may be varied in respect to several dimensions. One dimension extends from high levels of iconicity, or realism, to symbolic representations. A very high level of realism is seen in motion picture displays called "cinerama" which will be discussed later in this paper. At the other extreme of this dimension are highly abstract visuals such as diagrams, bar graphs, "swish" lines, mathematical symbols, and animations that in no way resemble anything seen in a natural environment. Such visuals are commonly employed to represent abstract ideas and relationships. In between these two extremes are pencil sketches, animated cartoons, and x-ray films.

Pictures which are highly or even moderately realistic may be varied in respect to color, full or half tone, dark or light, in clear focus or blurred. The same object or event may be photographed or otherwise pictured from many different angles and in many different perspectives. A picture may show one bird or a flock of birds, one building or a view of an entire city. Close-ups are often used in A-V presentations for aiding the identification of relevant cues. There are still other ways in which visual displays can be varied. One is the arrangements of the parts, another is the temporal order in which the visuals are shown. In fact, the visuals in A-V presentations can be varied in all of the ways known to the motion picture and graphic arts.

The problem of selecting from this vast storehouse of visual variables the ones that are most effective for motivating and cueing the responses required at the different stages of the learning process, and for different kinds of learning tasks, is indeed a formidable one.

The verbal auditory components of a presentation may also be varied in several ways. Two main classes of variables are recognized. One is the composition of the script and the other is the way it is narrated. Some of these variables have been investigated. Among them are levels of readibility of the script, the number of words spoken per minute or per footage of film, the number of easy and hard words in the vocabulary, the length of sentences, and length of words. Variations in the voice quality with which the script is narrated have not been investigated.

All A-V presentations, as the word implies, employ both visual and auditory stimuli in many different combinations. These combinations are composed of variables selected from both the visual and auditory possibilities. The problem now becomes very much more complex because of the increase in the number of possible permutations and combinations. The problem is further complicated by the fact that in some films the main load of information is conveyed by the verbals supplemented by visual aids. In other films the situation is reversed; the verbals are used to explain the visuals. In most films, however, there are mixtures of these relationships.

The foregoing references to the possible ways in which visual and verbal components may be varied experimentally, either independently or in combinations, indicate the complexity of the problem of assessing their values for motivating and cueing the responses required at each stage in the learning process.

2. Approaches to the Problem

There are a number of ways in which this problem may be attacked. Three are mentioned here. One is to begin with the experimental literature in which comparisons have been made between visual, auditory, and audio-visual presentations of the same materials.

This literature is quite extensive. It has been reviewed by Hoban and Van Ormer (1950), Day and Beach (1950) and Hartman (1964) and, in part, by Lumsdaine and May (1965). In most of these studies, comparisons are made between the amounts learned when the same material is presented visually vs. aurally, visually vs. audio-visually, and aurally vs. audio-visually. The results are in substantial agreement that audio-visual presentations are superior to both visual and aural. (Allen 1960) This conclusion seems to hold for many kinds of materials and different learning tasks. There are, of course, exceptions. One is the acquisition of speech habits. Language laboratories are equipped mainly with *auditory apparatus*.

Most of these studies are evaluative in character and do not provide much information on the conditions under which presentations through one sensory channel are superior to two channels. (See Lumsdaine 1963.) Furthermore, very few experiments have been reported in which visual and auditory stimuli have been varied in the many ways they can be, as indicated in the preceding paragraphs. Because of these limitations, the relevant experiment literature does not provide an adequate base from which the problem at hand may be approached.

Another approach starts with an examination of the many claims that have been made, by writers on audio-visual education, for the superiority of A-V presentations over other media, and over the conventional methods of teaching. Some of these claims have been summarized by Traver (1964) and need not be recounted here. Most of them are not stated in terms of propositions that can be tested by experiments.

The approach employed in this paper begins with a consideration of the basic properties of words and pictures. This is followed by an analysis of the responses required for learning from A-V presentations. After these two steps have been taken, consideration will be given to how knowledge of the basic properties of words and picture can be used to the relative merits of visual, auditory and audio-visual stimuli for motivating, cueing and reinforcing the responses that are specified by learning tasks.

3. Basic Properties of Words and Pictures

J. J. Gibson (1954) has advanced a theory of pictorial perception. Knowledge of the environment is acquired in two principal ways. One is by direct perception commonly called "first hand" experience; the other is by communication -- i.e., by being told, taught, shown, and informed. There are two main vehicles of communication -- language and nonlinguistic representations of objects, places, events and relationships. These are called "surrogates." A surrogate is a stimulus that will elicit the same or similar perceptual responses as the object, event or relationship for which it stands. The picture of a dog, or the word "dog" will elicit a perceptual response similar to that elicited by actually seeing a dog. There is, however, an important difference between the response elicited by the picture and the word. The picture refers to a dog of a particular size, shape and texture; the word refers to any dog. It is apparent that pictures have a higher degree of specificity than words. But pictures may vary in respect to degrees of specificity. A picture may be so vague, blurred, or sketchy that it will not elicit any one clear cut perceptual response. In this case the picture does not correspond to any specific object, place, event or relationship. Gibson calls this the lack of "fidelity."

Just as pictures may vary from high to low levels of fidelity, words may vary from high to low levels of "univocality." Their referents may be clear or ambiguous.

There is another way in which words differ from pictures. The referents of words are determined by convention. All linguistic symbols are determined by the customs and habits of different groups of people who speak different languages. Pictures, on the other hand, derive their meaning from projection or replication. The picture of a dog is perceived to stand for a dog to all people who have seen one. But the word for dog is different in most languages of the world. This is one reason why a picture is said to be worth 1000 words.

Gibson suggests that all surrogates can be placed on a convention-projection continuum with linguistics at the conventional pole and pictures at the projectional pole. Diagrams and graphs are between these poles.

The projective or picture-type surrogates have the advantage of concreteness and fidelity. But the greater the fidelity of a surrogate, the less is its capability to refer to abstract relations. Conventional surrogates are much less environment-bound and have a much greater flexibility and capacity. They can specify abstract ideas or concrete objects. Mixed types of surrogates are recognized. Examples are diagrams and charts which represent objects and relations, and "chirographic" languages. In general, however, "a chirographic picture cannot at the same time possess high fidelity for something concrete and high univocality for something abstract." (p.12)

Gibson's theory suggests that there are fundamental connections between the acquisition of knowledge by first hand experiences and by communication. Learning from pictures alone resembles, in many respects, learning by observing different aspects of the environment and environmental changes. The nonexperimental sciences of meteorology, astronomy, and geology are based on knowledge acquired largely by visual observations. A recent example is the new information gained about the surface of the moon from examinations of close-up photographs.

Knowledge of the environment is also acquired by manipulating parts of it experimentally, as illustrated by the sciences of physics, chemistry and biology. Experimental manipulations can be represented, both by conventional and projective surrogates. This capability has two great advantages. One is communication. The other is that the verbal and mathematical symbols which represent experimental processes can be manipulated on paper, so that predictions can be made concerning the outcome of experiments. All scientific theories are stated in terms of conventional surrogates. Some parts, however, may be "illustrated" by nonconventional representations.

This brief account of some of the basic properties of words and pictures does not, by any means, exhaust the topic. It is a subject that has concerned philosophers, psychologists and linguists, since the time of Plato. The relations between conventional and projective referents was argued in Plato's dialogue Cratylus.

A noteworthy advance was made by C. S. Pierce who in 1867 published a remarkable paper on what he called semiotics -- a theory of signs. He distinguished three types: index, icon and symbol. An index represents a physical contiguity between the sign and what it signified.

Examples are finger prints, foot prints, shadows, blood stains, etc. Icons represent factual similarities between signs and what they signify. The signifying power of symbols is bestowed by convention. Pierce went on to describe the characteristics of mixed types of signs. A diagram, for example is called "a symbolic icon" because it has the properties of both icons and symbols.

This pioneering work of Pierce stimulated a great many studies of the basic properties of the media of communication. Charles Morris (1946) has made noteworthy contributions to theory of signs.

4. Responses in Learning from A-V Presentations

Having noted briefly some of the principal properties of words and pictures, we turn now to an analysis of the responses required for learning from A-V presentations. For convenience of discussion they are put in three major categories: (a) responses that are preparatory to, and prerequisite for the acquisition of new knowledge; (b) acquisition responses; and (c) consolidating responses.

Preparatory Responses

1. Responses Involved in Paying Attention

These are of two major kinds. First, are the overt responses of sensory adjustments, sometimes called "orienting responses." The learner must be seated where the screen can be seen and the narration heard. He must look at the screen and listen to the narration. Second, are the covert responses of attending. This involves more than mere gazing at the screen and having the ears exposed to the narration. In everyday language, paying attention requires putting one's mind on the presentation, and keeping it there from the beginning to the end. The nature of the responses of attending will be discussed later. One criterion is that of ignoring all other environmental and internal stimuli.

2. Responses of Selective Attending

Most A-V presentations contain materials that are irrelevant to the learning task. It is essential, therefore, that attention be focused on the relevant cues, and that all irrelevant one be ignored. The responses involved at this stage are discriminative in character. The task of identifying and attending to relevant cues, and to no others, as they occur from sequence to sequences, scene to scene, and sentence to sentence, is not unlike that of sighting a gun at a moving target. Konorski has called them "targeting" responses. Stimuli that aid in the elicitation of these responses were called, in the previous paper, "cue identifiers."

3. Responses Involved in Understanding the Meanings of the Relevant Cues

Learning from instructional films and ETV programs belongs in the category of meaningful learning. It is essential, therefore, that the meanings conveyed by the relevant cues be correctly perceived. If they are not clearly understood, the acquisition of new information will be seriously hampered. If for example, the narration were in a foreign language and/or if the visuals were meaningless mathematical symbols, very little new knowledge would be acquired by students to whom these stimuli are perceived as "Greek." This, of course, is an extreme case. It is used to illustrate the importance of the correct perception of the meanings of the pictures, words, and graphic symbols used in A-V presentations.

Acquisition Responses

The three categories of responses indicated above are considered as preparatory to, and prerequisites of, the responses that are required for the acquisition of new knowledge. Acquisition responses are controlled by the learning task. Different kinds of tasks may require different kinds of responses. There may be, however, one or more types of learning that are basic to all meaningful learning.

1. Associative Responses

All verbal learning, both meaningful and rote, requires the formation of new associations between stimuli and responses. The stimuli may be verbal or nonverbal, but the responses usually are verbal. Learning is faster and better retained when the stimuli and response terms are meaningful, than when they are meaningless or nearly so, as in the case of memorizing nonsense syllables. Learning lists of names, verses of poetry, the vocabulary of a foreign language, the facts of addition and subtraction in arithmetic, facts of science, geography and other school subjects, are examples of meaningful verbal associative learning. Learning is meaningful when new associations are formed between terms, the meanings of which have previously been learned. If these meanings have not been learned previously, then associative learning becomes a matter of rote memorizing of meaningless words.[1] The result is "empty verbalization" which is frowned upon by educators.

2. The Acquisition of New Concepts

The learning tasks required by many A-V presentations go beyond the formation of new associations between terms and demand that fuller and more comprehensive meanings and implications of the materials be learned. In the language of audio-visual specialists this is called "concept" learning. This type of learning involves much more than merely memorizing dictionary definitions of terms such as "velocity," "rigidity" and "beauty." In psychological language a concept is defined as "any response, verbal or motor, that is under the discriminative control of a broad class of environmental objects or events," (Verplank, 1957). Terms such as "honest," "beautiful," "clever" are responses to discriminable properties of things and actions.

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[1] There is evidence that nonsense syllables and meaningless non-verbal materials are learned by endowing them with meanings which mediate connections between stimulus and response terms (see Osgood 1952, also Bugelski, 1962).

The process involved in concept formation occupies a prominent place in modern experimental psychology. The literature is very extensive.

3. The Understanding of Explanations

In many A-V presentations a major part of the learning task is grasping a new idea, understanding an explanation, or comprehending the full meaning of a principle. This is sometimes called "substance" learning in contrast to factual learning and concept learning. While the responses of grasping, understanding and comprehending the full meaning of a presentation involve the utilization of previously acquired associations and concepts, they also require a higher order of covert responding. This higher level is designated by Gagné (1965) as "principles" learning. Beyond is the higher level of problem solving.

Consolidating Responses

In order that new knowledge gained from a presentation be utilized either on a post-test or for the facilitation of further learning and become an integral part of a student's education, it is necessary that gains be consolidated and fortified so they will be available when needed. This may be achieved in several ways. Two are mentioned here.

1. Responses of Initial Reinforcement

The more firmly a response to a stimulus is reinforced in the learning situation, the greater is the probability that it will be elicited by similar stimuli in the test situation. Reinforcement depends on several factors one of which is the number of stimuli in the presentation that have the power to evoke confirmatory responses.

2. Review and Practice

Many films contain a review section at the end which is intended to aid the students in consolidating the materials that were learned. Although the existing experiments on the effectiveness of such sections indicate that they are not very useful (Lathrop and Norford 1949), there are reasons for believing that immediate review may be very useful.

The above analysis of the responses required for learning from an A-V presentation is not based on any particular theory of learning. It is, however, oriented toward S-R reinforcement theory. It is admittedly inadequate to account for all of the processes that are involved in the acquisition of knowledge from complex presentations. It is presented here to indicate that learning from audio-visual communication requires not one but, a sequence of responses. Furthermore, it emphasizes two important variables that cannot be overlooked. One is that learning from A-V presentations depends on a considerable amount of prerequisite learning; and the other is that most of the responses are specified by the learning task. No adequate account of the role of visual, auditory and audio-visual stimuli in learning from films can be given without taking into consideration these variables.

Other theoretical approaches are recognized. One is information theory. Travers (1964) has shown how this theory may be used as a model for attacking the problem of learning from A-V presentations. This model has a number of attractive and stimulating features. One is its simplicity. The relative merits of information theory and S-R theory will not be discussed here. Both have been, and will perhaps continue to be, productive of the research that is needed in this field.

Part II - Preparatory Responses

The three categories of responses included under this heading are those of attending, targeting, and perceiving. It is assumed that they have been learned prior to the presentation. Because they are prerequisite to the acquisition of new knowledge, it is essential that the presentation contain stimuli that will motivate and cue them. The kinds of stimuli that can perform these two functions should be similar, in some respects, to those to which they were previously conditioned. To the extent that they have not been previously acquired, they are an essential part of the learning task.

1. Responses of Attention

The overt orienting responses of getting set to view a presentation are elicited largely by situational cues and motivated by predispositional motivators. An experiment on the optimal distance students should be seated from the screen, on angles of viewing, and amounts of screen illumination is reported by Ash and Jaspen 1953. Problems of viewing arise mainly with children who have poor eyesight or defective hearing.

The covert responses of paying close and sustained attention are known by their antecedent and consequent conditions. One antecedent condition is that all competing external stimuli be removed. This is accomplished by a quiet and darkened room. Another condition is that all internal competing and distracting stimuli be ignored. The degree to which attention is concentrated on the presentation may be measured by the strength of the stimuli required to distract it. Another measure is the amount of the presentation that can be immediately recalled or recognized. And finally the strength of the attending responses is determined by the strength of the motivators and of the associations between them and the stimuli that control them.

Attention Motivators

The responses of attending may be motivated by any one, or any combination of, the categories of motivators described in the final section of the paper on "Enhancements and Simplification of A-V Stimulus Variables." Students may be motivated to pay attention either by high levels of school drives, interest in the topic, attractiveness of the presentation, a prefilm pep talk, or by being aware that the situation demands it.

The "eager beavers" who have high levels of achievement motivation can be counted upon to pay close attention to any classroom presentation however dull, or even nonsensical, as it may be. Other students who have special interests, and lack high achievement drives, will attend voluntarily to subjects that interest them. A crucial motivator is whether the topic or subject, is perceived as worth paying attention to. In psychoanalytic terms attending is the deployment of one's psychic energies on a particular task. It is a form of investment on which a fair return is expected. Interest in a presentation is not unlike interest on an investment. A student who feels that a presentation is not worth the effort is apt to sit and day-dream or even sleep. It is for students of this kind that some other motivators are essential for attending to presentations in which they have no interest.

Among these are situational motivators. In a classroom situation, disinterested students may attend because they know that they are expected to, and may fear the consequence of not attending. They may also be motivated by a prefilm talk on the importance of the subject or by an announcement that the test results will count on the term marks, or will be announced to the class. (See Allison and Ash, 1951, on the effectiveness of anxiety as a motivator.)

Another important motivator of attention is the manner in which the material is presented. Subject-matter that is otherwise dull and boring may be presented in a lively and attractive manner; and contrariwise, interesting material may be presented in a dull and monotonous way.

A major difficulty encountered in loading a film with attention-gainers and sustainers, which do not convey additional information and are therefore irrelevant to the learning task, is that such devices tend to interfere with other responses essential to the learning process. For example, a fast moving presentation would be expected to hold attention better than one that drags. When Jaspen (1950) varied the rate of development of a training film, in combination with other variables, he found the four most effective versions out of a total of seventeen had a slow rate of development. This was due, in some part at least, to the time that is required for the subjects to learn the associations. In other experiments in which the effectiveness of motivating embellishments were tested, it was found that they added no significant increments to amounts learned -- not because they were not good attention-gainers and sustainers--but partly because they tended to distract attention from the relevant cues, and partly because attentiveness needed no further motivation.

A problem which has not been investigated is how to present a dull and boring material in which students have no interest in a way that will attract and hold their attention. One approach to it could be to prepare two versions of a film -- one designed to gain interest, which would be presented first, and then a second version with the teaching materials. The first could be very fast moving, and embellished with all manner of attention-getters; the second would be slow moving with irrelevant embellishments removed. The purpose of the first version would be to arouse interest in the second (see May and Jenkins 1958).

Stimuli that Control the Responses of Attention

There are two classes of stimuli to be considered. The first is those that elicit the orienting responses of looking and listening. In common language these are the stimuli that "catch the eye" and "incline the ear." Any sudden change in the intensity of external or internal stimuli, such as a flash of lightning, a clap of thunder, a sharp pain, will command attention. The second is features of visual displays used in commercial advertising. A number of characteristics have been found to attract attention (see Woodworth and Schlosberg 1955). Among them are (a) novelty which includes any aspect of a display that is unusual or has a strange appearance; (b) contrast by which the important feature is made to stand out prominently against a background; (c) bigness which is indicated by full page advertisements, bill boards, and electric signs, and (d) special position. It has been found that the upper left hand corner or quadrant of a display tends to be the first to catch the eye. In addition to these visual characteristics there are other more general ones that will attract attention. An important one is any sudden change in environmental stimuli. In his famous chapter on the "Stream of Consciousness," William James compares it to the flights and perchings of birds. The perchings become the focal points of conscious awareness.

The characteristics of stimuli that attract attention are not necessarily the ones that sustain it. Responses of attending are characteristically of short duration (see, Dember 1960). It is almost impossible to hold attention on the point of a pin, a dot, or any other simple stimulus for more than a few seconds. Stimulus patterns which have been found by experiments to hold attention for longer periods of time have two principal characteristics. One is variety and the other is change. A complex pattern which contains a variety of features will permit attention to shift from one feature to another. Changes in the pattern, as in a motion picture, also provide an opportunity to capture the inevitable shifts in attention.

Experiments on young children by Schacter (1933), summarized by Travers (1954), indicate that they will attend to a complex performance longer than to a simple one. Research on attention to pictorial illustrations in books, summarized by Seth Spaulding (1955), show that "children prefer illustrations that contain action, that tell a story, that are related to previous experiences, and that can be associated with places, objects, persons, or animals about which they have read or are familiar with." These observations suggest that the characteristics of pictures that sustain attention are intelligibility, familiarity, and relations to personally significant events in daily life. These characteristics contribute to making the illustration "easy on the eye."

Experiments by Walters (1958) and by Solley and Murphy (1960) demonstrate that responses of attention are acquired by operant conditioning. They are learned instrumental responses that lead to goal responses and rewards. Children learn that it pays to attend to sudden changes in the environment, to moving objects, to strange objects and persons, and to commands by parents and teachers. In the classroom, attention to instructions from the teacher is rewarded and failure to attend is often punished.

The success of a film in gaining and holding the attention of students depends in no small part on the employment of stimulus patterns which by past experience have become conditioned to the responses of attention. This is illustrated by orienting responses. Most American school children have found that watching TV at home and movies in theaters are rewarding experiences. When a film is shown in school, the pattern of environmental stimuli is similar to that of TV seen at home, and to movies seen in the theater. This similarity in stimulus patterns will tend to elicit responses of attention in school.[1]

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[1] There may be, however, a fly in this particular ointment. It is that these same stimuli which elicit responses of attention, may also elicit responses of relaxation and enjoyment which will interfere with acquisition responses. Here is a problem that requires further experimental investigation. We shall return to it later in this paper.

A maximum amount of similarity between an A-V presentation and life experiences is found in modern theatrical projections, variously called "cinemascope," "cinerama," and Walt Disney's "circarama" at Disneyland. Here we have bigness, novelty, variety, contrasts, and change all combined. These displays simulate closely the experiences of being an eye witness to objects, places and events, and convey the feeling of being a part to the situations displayed.

These inventions and their appeals are summarized by Wagner (1955) who observes that "there is undoubted attention in amplification of an image, isolating the size factor" (p. 297). He refers to a result obtained by Adams that the attention value of an illustration is approximately proportional to the square root of its area.

Perhaps one of the reasons why displays such as Disney's Circarama is so attention compelling is that the viewer is so "swallowed up" that all competing stimuli are effectively shut out. Another illustration of the height to which attention can rise is that of being so absorbed in reading a book, or watching a TV program, that all other stimuli, both external and internal, go unheeded.

It is quite unlikely that such dizzy heights of realism as experienced in watching cinerama could be usefully employed in instructional films. As wagner observes, the power of an instructional picture "is not the fact that it reproduces reality, but rather that it intensifies, abridges, and reorganizes the real world, focusing attention of an audience on significant details, moving the spectator through an arranged, selective sequence of visual cues in a highly realistic way" (p. 298). The important thing about realism is that the picture be perceived as authentic and not a product of trick photography.

The power of spoken words to attract and hold attention has not been as well investigated as the power of nonverbal visuals. Comparisons that have been made between audio alone and audio-visual presentations of the same materials are illustrated by the experiments of Barlow and Westley (1959) and others, all of which indicate that audio-visuals are more effective than aurals alone. But these experiments are too molar in character to answer the question of the relative merits of words and pictures as attention-gainers and sustainers. There is some evidence, reported in the previous paper, that prefilm verbal instructions and attention-directing procedures are more effective than built-in visual devices such as color and comic cartoons.

The attention-gaining and sustaining power of words heard over radio, from a tape recording, or the sound track of a film, depend on a number of unexplored variables. We can only guess at what some of them may be. One may be the perceived prestige or importance of the communicator. Does he know what he is talking about? Another could be the quality of the delivery. If it is monotonous and without variety, one would expect it to induce a sleepy hypnotic effect. In fact, most of the attention-gaining qualities of visuals, such as contrasts, rapid change and uncertainty, might be applied to auditory stimuli. In any event here is a fairly wide open field that invites more needed research.

As indicated in a footnote above, stimuli which elicit responses of attention may also elicit responses of relaxation which compete with responses of acquisition. Furthermore, the stimuli that control the responses of attention may be irrelevant cues, and hence tend to distract attention from the relevant ones. One way around this difficulty would be to construct a film in which the pictorial content is designed to elicit only the responses of attention. The visuals in such a film would convey no relevant information, present no irrelevant cues, elicit none of the acquisition responses, and in no way facilitate responses of consolidation by adding anything to the organization of the content.

Two experiments in which some of these requirements are met are reported by Ketcham and Heath (not dated). They used a 26-minute film on the life and works of the poet, William Wordsworth. The narration contains a brief account of his life and works and quotations from some of his poems. The visuals are photographs of places where the poems quoted were written, and of the scenes that inspired them. The narrator made no reference to the visuals because they contain no additional information.

The subjects were 154 undergraduates in a course in English Literature. Half of them saw the film (the audio-visual group) and the other half (the audio group) heard the narration but did not see the visuals. Each group was split into three subgroups. One audio-visual subgroup saw the film once; another saw it three times; and a third saw it three times and took notes. One audio subgroup heard the narration once; another heard it three times; and the third, a control group, received conventional classroom instruction. Group difference in verbal aptitude was controlled by covariance. The criterion test contained 48 multiple choice items and was administered immediately after each presentation and again a month later.

On the test of immediate recall, the audio-visual version was superior to the audio for all comparisons. But on the test of delayed recall, the difference between the means of the two groups was not significant. Three showings produced better learning than one. This was true for both versions. Students with low verbal aptitude scores profited more from three showings than those whose scores were high.

These results indicate that the visuals in this film functioned to sustain attention to the narration. Although they conveyed no additional information, they did have a certain degree of relevance to the narration. The question arises as to whether or not visuals, that contain no additional information, must have some relevance to the narration in order to hold attention. In a pilot experiment, by the same authors, a series of 35 mm. slides were prepared in three versions: (1) pictures illustrating parts of the narration; (2) pictures of geometric forms; and (3) pictures of irrelevant scenes. Four groups of subjects were used; one for each version of the slides and a control group who received only the narration.

The version that yielded the best learning was narration with relevant picture; narration with geometric forms was next, and narration with no pictures next, and poorest of all was narration with irrelevant pictures.

It would appear that relevant pictures served to hold attention to the narration; irrelevant pictures distracted attention from the narration.

This result suggests a general hypothesis which asserts that pictures containing no additional information may be used effectively to hold attention to the narration provided they are relevant, in one way or another, to what is being said.

2. Targeting Responses: The relative merits of words and pictures for directing attention to, and focusing it upon the relevant cues

This step in the process of learning from A-V presentations is essential because: (a) attention is basically a selective process, (b) in most A-V presentations there are many different features that could attract attention, as noted in the preceding section; (c) some of these features are relevant and others irrelevant to the learning task; and (d) stimuli presented by different features vary in respect to their attention-directing and sustaining powers.

As noted in the preceding section, paying attention to a presentation is largely a matter of ignoring all competing external and internal stimuli. The focusing of attention on relevant cues requires that all irrelevant features in the presentation also be ignored. In the preceding section, some of the characteristics of stimuli that control the responses of attention were reviewed. The problem now arises as to what additional stimuli are needed to focus and hold attention on the relevant cues.

The solution to this problem lies partly in the fact that the relevant cues are controlled largely by the learning task. The effectiveness of pre-film instructions and attention-directing procedures, as reported in the paper on Enhancements and Simplifications, may be attributed largely to the manner in which they aid in defining the learning task. When students are told to look for answers to questions that are included in the post test, they will scan the presentation for the correct answers and will tend to ignore all other parts. A general rule may be that the more clearly and specifically the learning task is defined and understood, the greater will be the probability that the relevant cues are noticed. The target is defined by the task.

Specifying the learning task will, no doubt, greatly aid the learner in knowing what to look for, but he may still need help in recognizing a significant cue when he sees or hears it. At this point cue identifiers, emphasizers, and familiarizers, described at some length in the paper on Enhancements and Simplifications, come into play. It will be recalled from that paper that such devices are mostly visual. They are most effective for learning materials that are relatively new.

Experimental results obtained thus far would seem to indicate that the function of defining the learning task, in instructional films, is best performed by verbalized instructions and other verbal procedures. But the function of cue identification and familiarization is best served by visual stimuli. There are exceptions, however, to this tentative rule. If the learning task is a manual performance, it is best defined by seeing it demonstrated. In some presentations, significant cues may be designated verbally, particularly when the narration is carrying the heavier part of the instructional load. Furthermore, crucial cues may be identified audio-visually by calling attention to some feature of a visual display. This happens in illustrated lectures.

A rule breaks down when the number of exceptions exceeds the number of instances to which it applies. In this event, the rule has to be restated in terms of the conditions under which it will and will not hold up. Much more research is obviously needed before rules could be formulated stating the conditions under which visuals, verbals or audio-visuals are most effective for serving the functions of task definition and cue identification.

The simplest way for dealing with irrelevant cues is to omit them. In this event all cues are presumably relevant to the learning task. The problem then becomes one of sustaining attention. This sounds simple enough but it is doubtful if all irrelevant cues could be eliminated. One way to approximate it would be to select from a film only relevant frames and present them in a film strip as was done by Zuckerman (1954). Another procedure would be to picture a teacher reading questions one by one and pausing after each for student response. This technique was successfully employed by Gropper and Lumsdaine (1961). But even in these simplifications, the relevant cues may be embedded in contexts of irrelevant ones.

Another source of competition between the visuals and the narration is that a learner could be so absorbed in the visuals that he neglects the verbals, or vice versa. This, of course, rarely happens; yet during a presentation, there could be a rapid shifting of attention back and forth between the pictures and the narration. Recent experiments on competition and compromise between channels of sensory input by

Broadbent, and summarized by Travers (1964), indicate that when different information is presented simultaneously through two channels--the two ears--the output is all that went through one, followed by all that went in through the other. The output is not first a part from one then a part from the other (Travers, 1965, p. 7.05). This would seem to indicate that intake was by wholes. But whether attention shifted back and forth during intake is not clear.

Another condition on which the relative values of visuals, aurals, and audio-visuals depend, in relation to task specification and cue identification, is the relative amounts of information carried by the visuals and the narration. In the film used by Ketcham and Heath the information relative to the learning task was conveyed entirely by the narration. The visuals contributed little if anything to the focusing of attention upon the crucial cues.

There are films, however, in which a major portion of the information is conveyed by the visuals. The function of the narration is to explain the visuals. Relevant cues are identified by verbal references. Included in this category are films in which most of the information is presented in the form of charts, diagrams and graphs. In such films relevant cues may be identified, either visually by pointers, or verbally, or both. In some presentations the main function of the visuals is to illustrate and support the points made in the narration. A typical example is illustrated lectures and textbooks. Here the visual displays function not only to convey supporting information, but also, because of their intensity, novelty, and ease of identification, aid in focusing attention on the content of the narration.

It is recognized that we are dealing here with a very complex psychological problem which has ramifications that extend far beyond the limits of this paper. Some aspects of it are, however, researchable at the level of A-V presentations. Many of the variables can be manipulated experimentally. But to test their effectiveness in performing the functions of task specification and cue identification, there is need for a valid and reliable measure of how well these functions are performed. The usual type of post-test is inadequate because it measures the net effectiveness of all the steps in the learning process. It is possible that a learner could give the presentation his sustained attention and notice all of the relevant cues, and even ignore the irrelevant ones, and still not learn much, if anything, because of failure in subsequent steps.

Gropper (1963) points out a number of discriminations that may be required in order to notice and respond to the cues that are relevant to the learning task. One pertains to the boundaries between instructional units and boundaries between parts within a unit. Within each unit, or within a part of a unit, the crucial cue may be a particular attribute such as shape, size, color, the arrangement of parts, or a temporal sequence.

If such discriminations have not been previously learned, then part of the instructional task is to aid the learner in making them. These aids may be either visual, verbal or audio-visual depending on the type of discriminations that need to be learned. Learning to tell whether there are more pennies in a pile of one hundred than in a pile of ninety nine is extremely difficult. But if the piles are labeled with words or digits, and if these have been learned, the visual discrimination is made very much easier (see Dollard and Miller, 1950). The difference between oysters and clams, on the other hand, can be taught better by pictures than by labels or verbal descriptions.

3. Perceptual Responses

Attention to relevant cues is a necessary but not a sufficient condition of learning. Another condition is that the meanings of the important words and visuals be correctly perceived. Failure at this stage in the learning process will seriously interfere with the acquisition of new knowledge.

In the production of an instructional or ETV program it is assumed that the meanings of the words and pictures will be understood by students for whom the production is intended. This assumption is not always correct. Misperceptions may be occasioned by (a) failure to understand the meanings of some words in the narration; (b) mistaking the meanings of words that sound the same but are spelled differently; (c) failure to apprehend what a picture or diagram is supposed to represent or to illustrate; (d) mistaking the referent of an ambiguous picture or diagram.

Knowledge of vocabulary is an essential condition of both visual and aural verbal learning. All formulas for simplifying a narration include the substitution of shorter for longer words and easy for hard words selected from Thorndike's word list. Another element in simplification formulas is the substitution of short sentences for longer ones. Simplification is a procedure for insuring that the meanings of the words and sentences in the narration will be correctly perceived.

A second source of failure to "get" the intended meanings of words used in a narration is the number of words that are spelled differently and have different meanings but are pronounced the same. Examples are red and read, whole and hole, bear and bare, fare and fair, I'd and eyed, and many more. The intended meaning of such spoken words is usually provided by the context. When it is not, many curious and amusing misperceptions are made. For example, in a familiar hymn are the words: "The consecrated cross I'd bear" which a child understood to mean, "The consecrated cross-eyed bear." A student in geometry heard this sentence: "A whole is equal to the sum of its parts." On the test paper he wrote: "A hole is equal to some of its parts." A student heard a book referred to as being "little read" and thought it meant a "little red book."

Objects and places to which pictures refer are usually perceived accurately, provided the same or similar objects and places have been seen and can be recalled. The visuals most likely to be meaningless are diagrams, charts, mathematical formulas, and other graphic symbols that stand for abstract ideas. When such visuals are employed, their referents are usually explained by the narrator.

Ambiguous pictures and diagrams present a different problem. A picture of a building, for example, could be perceived as a hotel, apartment house or office building. In this case a verbal label is needed to indicate the correct referent. A pie chart with numbers in its segments could be perceived as a wheel with missing spoke, the numbers referring to how many are missing. Bar charts without labels could represent any kind of statistical data. Their meanings, however, are usually indicated by the use of verbal and numerical labels, and sometimes, by picturegraphs representing units or groups of units of statistics.

If meaningless or ambiguous visuals are not adequately labeled, or explained by the narrator, their meanings are likely to be misunderstood. There are still other sources of misperception. One is that spoken words may be indistinct and the visuals may be blurred as often happens when a film is badly worn or patched, and when the visuals of an ETV program are blurred by poor reception. Another is individual differences in abilities to make delicate visual and auditory cue discriminations.

Perceptual learning occupies a middle ground between preparatory and acquisition responses. In view of the fact that some presentations require instructions in the meanings of ambiguous stimuli, brief consideration should be given at this time as to how percepts are acquired.

No less than a half dozen theories of perceptual learning have been advanced by psychologists. They are reviewed by Drever (1960) and again by Gibson (1963). These reviews also contain a great many facts derived from a rapidly growing body of experimental literature on perceptual learning. Perceptual learning may be described in terms of Gestalt theory, value theory, information theory, cognitive dissonance theory, and S-R reinforcement theory.

The theory that fits best the theoretical orientation of this paper is the one advanced by Solley and Murphy (1960). They begin by pointing out the similarities between, and the interrelatedness of, perceptual and environmental learning. By operant conditioning the learner acquires knowledge of his physical environment and skills for dealing with it in a manner that satisfies his curiosity and other motivations. Perception is the process by which each individual constructs his own private version of his environment. This is achieved also by the processes of instrumental learning.

The perceptual environment is designated by Koffka (1924) as the "behavioral environment" because it is the environment that really controls a large part of human behavior. The responses that are made to the physical environment depend on how it is perceived. Also the responses made to the pictures and words in an A-V presentation depend on their perceived meanings. Individuals can learn to perceive the physical encironment realistically--veridically, or nonveridically according to their wishes. In Freudian terms it can be perceived according to the reality principle or the pleasure principle--in fact or in fantasy.

Environmental learning tends to mediate veridical perceptions. The more accurately the world of reality is represented in the perceptual world, the greater is the utility of perceptual learning as a substitute for environment learning. The greater the departure of the individual's perceptual world from that of reality, the less will be his ability to cope with his physical environment, and the greater will be the likelihood of landing in a mental hospital.

Perceptual learning from an A-V presentation requires the acquisition of veridical percepts. There are two aspects to this problem. One is that of acquiring correct percepts of new objects, pictures, and words;

the other is that of correcting previously acquired misperceptions. A great deal of psychological research has been devoted to this problem. One reason why pictures with high degrees of realism are recommended is that they are most likely to elicit the same perceptual responses as elicited by the actual objects, places and events which they represent. Stimuli that are unlike those presented by the environment are likely to evoke perceptual responses of uncertainty. This is one point where new perceptual learning can occur.

As indicated above, the steps in the process by which percepts are acquired parallel closely those by which first-hand knowledge of the environment is acquired by instrumental learning. These steps, according to Solley and Murphy, are: motivation, expectancy, attention, reception, trial and check, and the ensuing cognitive events and behavior. Although these steps are not conceived as a sequence of responses, it is difficult to see how they can be elicited and maintained without motivation, practice and reinforcement.

Stated briefly, and perhaps somewhat inadequately, the Solley-Murphy theory of perceptional learning goes somewhat as follows: the first step is motivation, instigated either by a bodily state of deprivation or by external stimulation. Motivation acts to energize and in some measure control the ensuing steps. A mechanism by which this is accomplished is outlined. Given the proper motivation the steps that follow are acquired by practice and reinforcement.

Perceptual expectancies are learned in a manner similar to that indicated by Tolman, and by modern probability learning theory espoused by Estes and others. They also correspond roughly to Bruner's "perceptual hypotheses," and to the so-called "unconscious assumptions" of the perceptual transactionalists. Expectancies when aroused, join with motivational factors in exercising control over the processes that follows--attention, reception, and trial and check.

Motivation plus expectancy function to direct attention to certain classes of stimuli, to the exclusion of others. Attention is defined in a manner similar to that given earlier in this paper.

The effects of attention on the steps that follow--reception and trial and check, are (a) selective, (b) integrative, and (c) energic. During waking hours, sensory receptors are bombarded with environmental energies that impinge upon them. It is essential that the organism be equipped with a selective mechanism which admits reception of some and rejection of others. As indicated earlier in this paper, attention is basically a selective process.

The integrative function refers to the fact that several features of an object can receive attention simultaneously when organized and arranged in certain ways. In reading, for example, we attend to entire words, phrases and even sentences, as wholes. This ability is learned. It corresponds to Woodworth's higher units.

The energic function serves to give emphasis to percepts and aids in making them more discriminate from each other, and from other processes such as ideas. The greater the concentration of attention on an object, the greater is the amount of neural energy deployed on looking, listening and examining.

Individuals learn to invest their available energies in different sensory modalities. Visual, auditory or tactile stimuli acquire different degrees of power to attract attention. In terms of psychoanalytic theory the investment of free energies in different sources of stimuli, such as in music or the visual arts, results in becoming cathexed to them. In terms of S-R learning theory, stimuli from different sources acquire different degrees of secondary motivating and reinforcing power which results in individual differences in interest in things heard and in things seen. Such differences have an effect on the ease with which visual and aural percepts are learned.

After attention comes reception, in the Solley-Murphy paradigm. Before an object is perceived it is first sensed. Percepts result from a variety of sensory experiences with the same object or kinds of objects. A classical illustration is that a cake of ice "looks" cold because it has previously been felt to be cold while being seen. Hence, by a process of sensory conditioning or reintegration, it will feel the way it looked and look the way it felt.

The final step in the paradigm is "trial and check" which is defined as the analyzing and synthesizing process by which tentative assumptions and sensory inputs are structured into percepts (p. 220). The phrase "trial and check" is borrowed from Woodworth who is quoted as saying, "the trial phase is a tentative reading of the sign, a tentative deciphering of the puzzle, a tentative characterization of the object; and the check phase is an acceptance or rejection, a positive or negative reinforcement of the tentative perception" (pp. 221-222). Bruner, Postman and other psychologists have named this phase "hypothesis testing."

The trial and check phase is most prominent when the stimulus input is ambiguous, when it fails to square with expectancies and established judgmental schemata, or does not fit into any pre-established category. "Trial and check functions to give meaning to perceptual traces, and by so doing it completes the perceptual act with its reinforcing role." (p. 225)

The achievement of meaning is the goal toward which the steps in the perceptual act lead. The problem of how sensory stimuli acquire meaning is a very old one which goes back to the era of pre-experimental psychology. Modern theories of how meanings are acquired are discussed by Osgood (1952) and more recently by Bousfield and Osgood (1961).

The Solley-Murphy theory of perceptual learning has been described at some length, not only because of the importance of perception as an essential step in learning from A-V presentations, but also because the analysis throws considerable light on how misconceptions may result from failure at any step from motivation to the trial and check phase.

Motivation, for example, can be seriously contaminated with "autism." People are often prone to attend to the things they want to attend; notice the features they want to notice; perceive them to mean what they desire them to mean. Such perceiving usually results in non-veridical perceptions. Fantasy becomes confused with reality. The pleasure principle dominates the reality principle; internal stimuli override external ones. External stimuli are perceived to mean what the individual would like to have them mean, and structured to fit desires and wishes rather than the world of reality. Persons whose percepts are autistically dominated are usually not aware that reality is being distorted. Such misconceptions are extremely resistant to extinction.

The role that autism may play in failure to learn from an A-V presentation is a problem for investigation. In most cases, it may be of minor importance, in others it may well be one of the reasons why some students fail to learn. Whether auditory stimuli are more likely to be autistically distorted than visual stimuli is also a problem worth investigating. Misdirected expectancies, or over-expectancy may also be a source of misperception in learning from A-V presentations. A particular scene or sequence in a film may arouse a false expectancy of what will follow. Then the perception of the stimuli that follow will be influenced, to some degree, by false expectancy. This possibility is amenable to investigation by presenting sequences in a film strip that are rigged to arouse correct vs. false expectancies, and requiring the subjects to guess what the next frame will be.

At the attention-reception stage two things could happen that would result in misperception. One is the case in which the crucial cues are dim, blurred or otherwise distorted; and the other is that the A-V channels are overloaded with so much sensory data that some of the essential ones are filtered out (see Broadbent, 1958, and Travers, 1964). Furthermore, there is considerable evidence, both experimental and anecdotal, indicating individual differences in channel sensitivity to stimuli. Blind people learn to make finer discriminations between auditory stimuli than seeing people; and the deaf learn acute visual discriminations as illustrated by lip reading. Among students with normal hearing and eyesight there may exist individual differences in sensory acuities due to past practice. Although this may be a minor factor in learning from A-V presentations, it could be easily investigated by testing the auditory and visual discriminating abilities of experimental subjects.

Another source of misperception in an A-V presentation is individual differences in sensory preconditioning. For example, after a little practice in hearing the word "red" while looking at a red object, hearing of the word "red" will tend to acquire the same stimulus value as seeing a red object. The name of a color then has been discriminated from other colors and has the same cue value as seeing the named color. This assumption can be made for a great many discriminations, but not for all. The name of an object may or may not be an adequate cue for eliciting a correct percept of it.

The time required by the trial and check phase, in the Solley-Murphy paradigm, may be too short for the process to reach a satisfactory, and hence a reinforced, percept. If the process is interrupted by lack of time, two things could happen. One is that the learner could be left in a state of frustration and uncertainty, and hence no perception; the other could be that the last trial before the interruption would get reinforced (ala Guthrie) and a misperception would result. This suggests that the tempo of development of a presentation should be regulated according to the degree of familiarity that the subjects have with its contents. The greater the amount of new perceptual learning that is required, the slower should be the tempo, up to a certain optimum limit.

The foregoing paragraphs may be summarized by noting (a) the correct perceptions of the meanings of the words and pictures in an A-V presentation are an essential condition for achievement of the learning task whatever it may be; (b) perceptual learning parallels instrumental environment learning and is controlled essentially by the same conditions of expectancy, attention, reception, and trial and check; and these conditions are quite similar to those involved in the process of learning from an A-V presentation.

Part III - Acquisition Responses

A. Introduction

Included in this section are all of the responses which A-V presentations purport to teach. They are contingent upon the preparatory responses described in the preceding section, which are commonly assumed to have already been learned. Also some of the responses which a presentation is designed to teach may have been previously learned by some students. This is evidenced by scores on pretests. In fact, learning can occur at any one of the steps in the entire process. As noted at the beginning of this paper, the division into preparatory, acquisition, and consolidation responses is made for the convenience of exposition.

1. Acquisition responses are specified by the learning task. All A-V presentations require close and sustained attention. Beyond this first stage, the particular responses made to the audio-visual stimuli are specified by the learning task. The cues on which attention is focused must be relevant to the learning task. The meanings attached to the relevant cues are also, in some respects, determined by the learning task.

If the task is to reproduce the materials verbatim from memory, the responses required to perform it are different from those that would be required to produce evidence that the substance of the material had been comprehended. If the task is to perform a sequence of acts, such as knot tying or assembling the parts of an automobile ignition distributor, the responses required by the demonstration are also different from those required by verbal learning tasks.

Before any useful statement can be made about the roles of visuals and verbals in motivating, cueing and reinforcing acquisition responses, it is necessary to know what kinds of responses are being considered and the conditions on which they depend. For example, if the task is to acquire a perceptual-motor skill, or to memorize a list of names or verses of poetry, or to form a new concept, a number of repetitions or amounts of practice may be required. But if the task is to understand an explanation, or to grasp a principle, a single presentation may be sufficient. As to the relative roles of words and pictures, it is rather obvious that a motion picture of a performance is much more helpful for cueing the correct manual responses than a verbal description of the performance or a set of verbal instructions. The relative values of words and pictures in teaching the binomial theorem or the second law of thermodynamics might be quite different.

2. A suggested taxonomy of learning tasks. In order to proceed, there is need for a taxonomy of learning tasks, based on and related to a taxonomy of educational objectives, and articulated with the characteristics of audio-visual materials. One source of materials for such a taxonomy is the large number of evaluative studies that have been made in which A-V presentations have been compared with conventional methods of teaching. This has been done for practically every subject in the curriculum from the first grade through graduate and professional schools. The list of such studies is long.

The latest report on the number of studies initiated under Part A of Title VII of the NDEA, from 1958 to 1964, list the following: in social studies and behavioral sciences 58; in the physical sciences 44; in the biological sciences 38; in mathematics 34; in the language arts 31; in foreign languages: 31; and in the humanities 15. In practically all of these studies a criterion test was used. An examination of the items in the tests (if they have been preserved), might provide useful data for the construction of a taxonomy of the kinds of tasks which A-V materials attempt to teach.

Without the benefit of information that might be derived from such a study, a crude analysis of learning tasks is presented here. It is not claimed to be exhaustive. Its purpose is to serve as a kind of map for guidance through a considerable amount of unexplored territory. The two main divisions into reproductive and productive tasks were suggested by Gagné (1962).

I. Reproductive Tasks

Included in this category are all tasks in which the learner is required to reproduce or to recognize a reproduction of, the whole or a part, of the materials learned. Some are:

1. Verbal reproductions--illustrated by experiments on memorizing. Included here are such tasks as memorizing and reproducing lists of words, verses of poetry, paragraphs of prose. Also are included tasks of learning the vocabulary of a foreign language.
2. Manual reproductions. Included here are most of the tasks involved in the acquisition of perceptual motor skills.
3. Pictorial reproductions. Included here are tasks of reproducing the materials learned by drawing and copying from a model.

II. Productive-Constructive Tasks

In this category are all the tasks that require evidence that the substance of the material was comprehended, and can be utilized in other situations. Examples are:

1. The task of recognizing an item of information or an idea when it is stated in terms different from those used in the learning situation.

2. The task of writing, in the student's own words, the substance of materials learned, as in the typical essay-type of examination.
3. The task of reproducing an explanation in the students own words.
4. The task of giving examples of a concept.
5. The task of solving problems similar to those given in the presentation.
6. The task of translating a foreign language.

3. Processes and products of learning. It will be noted that this classification is based on the products rather than the processes of learning. When we speak of learning by classical conditioning, operant conditioning, discrimination, assessing probabilities of reinforcement, memorizing, insight and problem solving, we are speaking of the processes, not the products of learning. At this point the problem arises as to how to match processes to products. Which of the various types of learning are required by, or best suited for, the achievement of types of learning tasks? In a recent volume edited by Melton (1964) seven distinct categories of learning are recognized and discussed by fourteen authors. Gagné (1965) has identified eight types of learning arranged in a hierarchial order. There is a considerable amount of overlap between

Melton's seven categories and Gagné's eight types. All of them have been shaped out of laboratory experiments on animal and human learning.

Learning from an A-V presentation appears to involve a mixture of these types. The problem is to discover which of the various types best fulfill the conditions on which the achievement of different kinds of learning tasks depends. Such a discovery would greatly simplify the task of assessing the relative merits of words and pictures for motivating, cueing and reinforcing the response required by different tasks. It would also enable us to apply to classroom learning many of the facts and principles derived from experiments on laboratory learning.

In the discussion of acquisition responses that follows, an effort will be made to relate them to the type of learning that seems most appropriate to each type of task.

B. Responses Required by Reproductive Tasks.

Consideration will be given first to responses required by reproductive tasks, which include verbal, pictorial, and manual reproductions of the learned materials.

1. The role of words and pictures in the learning of verbal associations. An illustration of this type of task is learning the vocabulary of a foreign language by the method of paired-associate. Pioneering research was done on the problem by Lumsdaine (1958), and by Kopstein and Roshal

(1954), Kale and Grosslight (1955), Bern (1958) and Asher (1961). These studies are summarized by Hartman (1961).

Lumsdaine (1958) prepared a large number of pairs of unrelated words, pairs of unrelated pictures, pairs of picture and words, and pairs of words and pictures. The pairs were presented in random order, 16 pairs to each list, to intermediate grade school children and to college students. The experimental conditions were varied in respect to rate of presentation and in other respects.

The members of each pair were selected to minimize previously learned associations. The learning task was mainly that of rote memorizing. It was found that under all conditions and for different grade levels of students, picture-word pairs were learned best, word-picture pairs least, with word-word and picture-picture in between.

The importance of this experiment lies in the theoretical reasons why pictures are better stimulus terms than words. One reason is based on the principle of temporal contiguity. While looking at a picture a person can simultaneously say a word out loud or silently, but while looking at a word it is difficult to say another word at the same instant of time. Furthermore it is impossible to say two words at the same time. The response word to a picture can be practiced while looking at the picture, but to practice saying a name of a picture while looking at a word is much more difficult.

Words are poorer stimulus terms than pictures mainly because they are apt to have more than one meaning. The word "fence" for example, may mean a barrier, or a dealer in stolen goods. But the picture of a barrier is perceived as a fence and not as a dealer in stolen goods. Words are better response terms than pictures partly because most people have had a great deal more experience in seeing an object or picture, before hearing or seeing its name, than vice versa. Furthermore, in Lumsdaine's experiment the criterion task was always to name the response term when the stimulus term was presented. When a picture was presented it was necessary to recall the word associated with it, but when a word was presented the subjects were required to name the picture that had been associated with it.

In this connection it is noted that when Bern (1958) changed the criterion task from recall to discrimination, presenting both words and pictures in the test situation, he found that for the performance of this task, picture-picture and word-picture were superior to word-word and to picture-word. Thus it would appear that when the criterion task is changed the associations that mediate the correct responses are different.

The role of mediators in paired-associate learning was investigated in an experiment by Davidson (1964). The materials were pairs of pictures of objects familiar to second grade school children who

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served as subjects. They were divided into a high and low ability group based on the results of a preliminary experiment, in which they were tested for initial abilities to form associations between pairs of pictures. Each of the two groups was assigned at random to five experimental conditions. For each condition twenty pairs of pictures were exposed at the rate of a pair every five seconds. There followed two test trials during which only the stimulus picture was exposed and the task was to choose from four pictures in a work book the one that belonged to the stimulus picture. On the second trial the order of presentation was changed.

For condition A no mediators were employed. For condition B the experimenter pronounced the names of the two pictures (e.g. "chair"-"shoe") on the presentation trials, but not on the test trials. Condition C was the same except the experimenter inserted a preposition between the pairs (e.g. "chair under shoe"). For condition D a mediating sentence was used such as "the chair doesn't look large under a big shoe." For condition E the picture showed a big shoe on a chair.

The mean scores (maximum 40) took a big jump beginning with condition C where connective mediators were introduced; for the high ability groups the jump was from a mean of about 13 to 33, and for the low ability groups it was from about 10 to 26. At the level of conditions D and E where sentences and pictures were the mediators the low ability groups had combined mean score almost as high as the combined means of the high ability groups. When pictures of relations (such as a big shoe on a chair) were added to sentences the combined mean score of both groups went up about five points.

Thus it would appear that when powerful mediators are introduced children of both high and low associational abilities can achieve almost perfect scores on two trials. Pictorial mediators added more scores to sentences, than sentences added to prepositions, and both added substantially more to the pronunciations of the names of the two pictures.

The role of words and pictures in paired-associate verbal learning has been further investigated by studies of learning the vocabulary of a foreign language which has an origin different from English. Two studies on the learning of Russian vocabulary have been reported. First Kopstein and Roshal (1954) found that picture-word combinations were superior to word-picture confirming Lumsdaine's results. The second was by Kale and Grosslight (1955) who translated Russian nouns and verbs from the Cyrillic alphabet to English equivalents and presented paired lists in five versions of a film. In one version, pairs of words were presented with English words always in the stimulus position. In the second and third versions, English-Russian nouns were presented below a picture of the object denoted by each noun. Each pair of verbs was shown below a motion picture depicting the action denoted by the pair. The fourth version was the same except that the printed words were pronounced by the narrator. In the fifth version, the students repeated the pronunciations after the narrator.

Ten films were used, five for verbs and five for nouns. Each version contained twenty pairs. The procedure was to present the pairs in each list at a rate of 5 to 11 seconds each. After a preliminary presentation of each list, six test trials were run in which each English word was exposed briefly and the subjects required to write its Russian equivalent on a workform while blank film was exposed for 10 seconds, after which the correct word was flashed on the screen. The criterion was the number of Russian words spelled correctly or nearly so on each trial.

The main variables in the presentations were (a) words alone; (b) words with pictures; (c) words with pictures plus pronunciation; (d) audience vocalization of the words; (e) fixed vs. random order of pairs; (f) pictures and Russian words alone vs. pictures of English-Russian pairs. Under all of these conditions the presentations with pictures, both motion for verbs and stills for nouns, were more effective than presentations without pictures. Pictures shown in combinations with pairs were somewhat more effective than pictures with Russian words alone.

This result would seem to indicate that on the test trials where the English word was the stimulus and the task was to write the Russian equivalent the picture functioned to mediate the correct response. The order of associations could have been:

$$\begin{tikzcd} \text{English word} \arrow[r, dashed, dash, "(1)"] \arrow[rr, dashed, bend right, "(3)"'] & \text{Picture} \arrow[r, dashed, dash, "(2)"] & \text{Russian word.} \end{tikzcd}$$

It was easier to learn association (2) than association (3) provided association (1) had previously been learned. In terms of classical conditioning the picture functioned as the unconditioned stimulus which reinforced the power of the conditioned stimulus (the English word) to elicit the conditioned response (the Russian word).

The pronunciation of the pairs of words by the narrator tended to interfere with learning. In all comparisons of pronunciation vs. no pronunciation on tests of immediate recall, the mean learning scores were less when the pairs were pronounced. But this was not the case on tests of delayed recall. The authors conjectured that one of the reasons for the interference was that a transliterated Russian word is not necessarily pronounced according to the English rules of phonetics. In writing a Russian word in the English alphabet the subjects were perhaps guided by how it would sound in English.

The conditions of the foregoing experiments on the relations between words and pictures in rote verbal learning of paired-associate are different from those involved in associative learning from A-V presentations in two fundamental respects. First, associative learning from A-V material is more meaningful; second the words are usually presented orally instead of visually. Further experiments are needed in which the pairs are more meaningfully related, and presented orally.

The interrelationships between aural and visual presentations have been investigated by Asher (1961) in a series of three experiments on learning Spanish vocabulary. One group of college students learned lists of Spanish words visually and, after 48 hours, relearned the same lists aurally; another group learned the same list aurally and relearned them visually. There were ten lists of about 10 words in each list. After all lists had been learned and relearned, all subjects were given a story to translate that contained the words in all of the lists.

In the first experiment, each English word was printed on a card with two Spanish words. Each subject was required to choose the correct one. The subjects who were learning visually were shown the three words and required to write the correct choice; the aural subjects heard the three words pronounced and were required to pronounce the correct one. Immediately after each response the subject was told whether it was right or wrong. After two correct responses the card was dropped from the list. The score for each list was the number of initial and perserveration errors. This same procedure was used in the relearning sessions.

In the second experiment, pairs of pictures and their Spanish names were presented at intervals of one second per pair for each list of ten pairs. On the test trials, only the pictures were presented and the subjects required to write or pronounce the correct Spanish word. The third experiment was the same except that English words were used instead of pictures.

Forty subjects participated in each of the experiments. Twenty learned aurally and relearned visually; and 20 learned visually and relearned aurally. All subjects were unfamiliar with the Spanish language.

All subjects were pretested for sensory dominance and for guessing ability. Sensory dominance was measured by requiring all subjects to learn an initial list visually, and another list aurally. Students who made the fewest errors on the first list were considered visually dominant; those who made the fewest on the second list were considered aurally dominant. Students who guessed the correct answer on the first presentation of a pair the most times on each list were considered to be the best guessers. Guessing ability was found to be highly correlated with all other measures of learning.

Under all conditions the students who learned visually and relearned aurally made fewer errors in learning than those who learned aurally and relearned visually. Among those who learned visually, the visually dominants learned somewhat better than the aurally dominants; and of those who learned aurally and relearned visually the aurals made fewer learning errors than the visually dominants. The correlations between guessing scores and learning and relearning scores were significantly positive; but significantly negative with scores on retention tests. Furthermore, the retention test scores of those who learned visually were not significantly better than for those who learned aurally.

This final result indicates an interesting relation between learning and retention. It supports the hypotheses that, regardless of the channel through which verbal materials are learned, retention is mediated by the sensory dominant channel. Visually dominant subjects recall materials learned aurally in terms of how they would look; and aurally dominant subjects recall visually learned materials in terms of how they would sound when pronounced. If this hypothesis is correct, it is of extreme importance for assessing the roles of visual and auditory stimuli in A-V presentations.

2. The Role of Visuals and Verbals in Learning to Perform Skilled Acts. Two different kinds of learning tasks are immediately recognized. First are tasks performed with one's hands such as handwriting, drawing from a model, tying knots, assembling the parts of an instrument, playing golf, tennis, and so on. The second are tasks performed with one's speech apparatus, as illustrated by learning to pronounce words correctly, to

speak fluently a foreign language, to sing, to whistle, and so on. In between are tasks that involve both the hands and the lips such as learning to play a musical wind instrument.

It is obvious that in learning to perform manual tasks visual or audio-visual presentation should be more effective than merely being told how to do it, or given printed instructions in how to perform it, as every American father on Christmas morning knows all too well. It is equally obvious that in learning vocal skills, auditory demonstrations are more effective than visual ones. It is true that deaf children can learn lip reading, and blind children can learn manual performances. But such learnings are very difficult and require a large amount of practice and patient teaching.

Most of the experiments on the roles of visuals and verbals in learning from demonstrations are found in studies on perceptual-motor learning, in studies of speech, and learning to speak a foreign language. Such experiments, unfortunately, were not designed to test the relative merits of words and pictures for performing the functions that are required by these learning tasks. Needed are some experiments designed to test hypotheses such as the following:

(1) The hypothesis that visual demonstrations are more effective than verbal descriptions for defining the learning task, not only in respect to the end result, but also in relation to the steps required to

achieve it. It is further hypothesized that a visual-demonstration of the performance plus a verbal description of the steps would be even more effective.

(2) Experiments performed thus far demonstrate that the function of cue identification by pointers, circles and labels is more effective than verbal directions alone. Would combinations of visual-verbal may be even more effective?

(3) The hypothesis that visuals in motion are more effective for the formulation of a "perceptual blue print" (Sheffield, 1961) from which the correct sequence of response in performing a skilled act can be read off than a verbal description of the sequence of movements. This hypothesis should be checked against May's theory (see below) that verbals often do play a significant role in learning from a demonstration.

(4) The hypothesis advanced by Gropper (1963) that seeing oneself perform a task correctly is more reinforcing than merely being told that it is correct on the ground that "seeing is believing" should be checked by further experimentation.

May's argument (1948) is that covert verbal responses to a demonstration as it is being viewed perform a function similar to that of Sheffield's visual perceptual blue prints. If during a demonstration the viewer tells himself what responses are made at each step, or repeats to himself what the narrator tells him, this sequence of verbal responses will become conditioned to the sequence of visual stimuli, which in the test situation are similar to those in the learning situation, and hence will serve to cue the correct sequence of responses. As the performance becomes more practiced these verbal mediators will tend to drop out, and thereafter the cues that control the correct sequence of responses will be largely visual and proprioceptive. Eventually the visuals may drop out and the learner can perform the act with his eyes shut.

The model for this theory of learning from a demonstration is that of delayed imitation, described at length by Dollard and Miller (1941). A driver finding his way through a maze of city streets by following a leader car, is a case of immediate imitation. But finding one's way later without the benefit of a leader depends on how many cues were noted and recalled as to where to make right and left turns. In this case the performance is guided by verbal recall of the cues. So in learning from a demonstration film, if the learner can verbalize self-directions for each step, and remember them in the test situation, he can successfully perform the task, provided these self-induced verbal directions have already acquired the power to elicit the correct responses. The verbal responses are elicited by the similarities between sequences of visual stimuli in the learning and in the test situations.

This section on associative responding may be concluded by noting that the formation of associations between stimuli and responses usually requires some sort of a mediating link. (See Gagné, 1965 p. 99). As noted above, the association between visual stimuli presented by the steps in a demonstration and the responses required for its performance may be mediated effectively by words. The association between English words and the Russian equivalents may be mediated by pictures or by some other kind of linkage. Thus, for some learning tasks, words serve the function of mediators better than pictures; for other tasks, pictures or visual images are more effective than words. Psychological studies of the mechanisms involved in associative learning indicate that visual images are often used to link pairs of words (see Cofer, 1961). For example, the pair of words "bow-trousers" is apt to elicit a visual image of trousers on a bow-legged man; "spoon-mailbox" elicits an image of a spoon lying in a mailbox. Other linkages may be provided by a knowledge of the derivation of words, such as terra-earth (mediated by terrestrial) (from Gagné, 1965 p. 101).

The more meaningful the terms to be associated, the easier it is to find linkages. The terms "terra" and "earth" have almost the same meaning. In contrast the syllables "Zok-bif" require much more inventiveness to construct a connecting link.[1] This illustrates the importance of perceptual learning as a prerequisite to associative learning.

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[1] Bugelski (1962) found that some subjects connected a pair of nonsense syllables, dup-tez, by translating it into "deputize."

A pair of associates may be regarded as a chain of three links. Learning lists of words or verses of poetry constitutes a chain of many links. Learning that Mt. Kinley in Alaska is 20,300 feet high, making it the highest mountain in the United States, is an example of verbal chaining that is characteristic of factual information learning. The conditions on which such verbal learning depend are discussed by Gagné (1965, p. 103-112). One of the conditions is that the meaning of each link in the chain must have been previously learned and discriminated from other links, and that the mediators between links must have been previously learned. Most of this previous learning is designated in this paper as perceptual learning.

C. Responses Required by Constructive Tasks.

1. At this point we turn from the reproductive types of learning tasks to productive-constructive types. Many A-V presentations require more than perceptual and associative learning. The tasks are, grasping an idea, understanding an explanation, comprehending a general principle, and solving a problem. Learning to perform these tasks from one or two presentations requires a considerable amount of previously acquired relevant knowledge which can be recalled and applied to the tasks. Lumsdaine (1958) found that the amount of the gap between previously acquired knowledge about the phenomena of osmosis,

as measured by a pretest, and a perfect score on the post test filled by one presentation was considerably greater for students with the higher pretest scores than those with the lower scores. The more a subject already knew about the topic, the greater was the percentage of new knowledge gained from the film.

The question now arises as to what kinds of previously acquired knowledge are needed to understand an explanation or to grasp a new idea, or to comprehend the substance of a presentation. First of all, the student must be able to perceive correctly the new meanings of the words and sentences in the narration and in the visuals. To the extent that these meanings have not been acquired, an amount of perceptual learning will be required. Second, the learner should have acquired associations between objects, places, events and relationships. Mediational linkages between stimulus and response terms, or units, must have been acquired and retained. Third, previous conceptual learning may be very useful. Knowing the names of the classes or categories to which the verbals and visuals belong, and knowing what the cues connote, as well as what they denote, should be helpful. To the extent that the necessary concepts have not been formed, conceptual learning will become part of the new learning task.

These prerequisites to substance, or idea learning, may be viewed as types of prelearned instrumental responses that lead to the goal responses of correctly and fully comprehending the materials in the presentation. The better these instrumental responses have been learned, the easier it is for the learner to march straight ahead to the goal without hesitating, hemming-and-hawing, and trial and error. If these instrumental responses have not been learned, or learned but not applied, then a considerable part of the instruction in an A-V presentation is precisely that of telling, illustrating, and demonstrating, the correct instrumental responses. (see Gagné 1962)

Assuming that students have already acquired these prerequisite kinds of knowledge, then what kinds of further responses must be made to the material in order to perform the criterion task successfully? What, for example, is required by a comprehension reading test beyond a knowledge of vocabulary and sentence structure? What responses must a student make to a paragraph in order to answer correctly the test questions about the idea or ideas that it conveys? What responses must a student make to an A-V presentation in order to "get" the new information that it conveys, or to comprehend its full meaning?

Many instructional films teach both facts and explanations. Students may learn the facts but fail to grasp the explanations. This point is illustrated in a study by May and Lumsdaine (1958). They noted that students who had had previous instruction on the phenomena of osmosis made much greater gains on questions of facts about temporary osmosis than on questions about the explanations of these facts. But for explanations about permanent osmosis the results were reversed. This difference was traced to the fact that the animated diagrams illustrating the passage of molecules of different sizes through semipermeable membranes were much clearer and more easily comprehended for the phenomena of permanent than for temporary osmosis (see p. 157). This illustrates the importance of animation that clearly depicts an explanation. The correct responses to questions about explanations were perhaps mediated by the retention of visual images of the animation. They aided the students in grasping the explanation.

2. The role of words and pictures in the construction of new concepts. For the purposes of this paper a concept is any class or category of objects, events, relations or stimulus elements, that share one or more common properties, and which can be identified by a label or a definition. Most concepts are abstract because their identifying properties are abstracted from concrete percepts. The concepts of length, volume, velocity, position, tallness, squareness, nouns, verbs, etc. do not refer to any particular object or word. They are labels for definable categories.

From the standpoint of behavior, the label or definition of a class of objects, or relationships, can elicit a response of naming a member, or giving an example. Conversely, an example in the stimulus position can elicit the name of a label or a definition. Concepts are, therefore, of great importance for classifying and organizing knowledge so that it is retained and can be used. The fact that they are associations which function both as cues and responses is of signal importance (Kendler, 1964) (see also Goss on the "Acquisition of Perceptual Schemes," 1961).

New concepts may be formed either by discovery or by instruction, or both. In laboratory experiments, the learning task is that of discovering the features or properties which arrays of stimulus patterns have in common. A strategy often employed by experimental subjects is to make guesses or form hypotheses about possible key features, from the initial presentation, and test them by observations of other examples. This is quite similar to the trial and check phase in perceptual learning. If the key cue is only one feature, such as size or shape or color, learning is fairly rapid; but if it is a particular size plus a particular color, in a particular position, learning is much more difficult. But once the key feature, or combination of features, is discovered a rule is formulated which controls the correct response to further examples.

Such rules can be taught without requiring the learner to go through the long and tedious process of discovery.[1] The rule can be communicated in the form of an operation definition. The students are simply told that if a pattern contains an element that is square and red it belongs to a class. If the class can be named by a common noun or nouns, such as "red squares" these words will then control the correct response to subsequent examples. But as Gagné (1965) has pointed out, the new concept is composed of two previously acquired concepts of redness and squareness.

A-V presentations usually attempt to teach new concepts by definition and examples. The success of this procedure depends on a number of factors such as the choice of words by which the concept is defined, and the amounts of previous perceptual and associative learning that is relevant to the task of comprehending the full meaning of the concept. Take for example a concept that may be new to some students--that of citrus fruit. This concept may be introduced simply by stating that citrus fruits are oranges, lemons, limes, grapefruit, tangerines, and others.

It is assumed that percepts of oranges, lemons and other examples have previously been formed. Differences between them can easily be perceived. But in what respect or respects are they alike?

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[1] Homme and Glaser (1960) developed a system for writing frames for a program of instruction in terms of rules and examples. It is called a ruleg system.

Why are they called citrus fruits? One common property is that they all contain relatively large amounts of citric acid. But what is citric acid? It is defined chemically as C_6, H_7, O_8. But this definition is nonsense to students who have not studied chemistry. The point is that until the concept citric acid has been clearly formed the words "citric acid" means only a kind of an acid that is found in one class of fruit. This example illustrates the point that the most distinguishing feature is not easily perceptible unless one's taste has been educated to the level of being able to identify a citrus fruit by tasting it. This being the case, the concept remains in a state of partial formation. From a practical standpoint this is no great disadvantage. The class of citrus fruits is relatively small. The concept can be acceptably formed by naming its members. Any fruit that is not on this list is known not to be of the citrus variety.

When the instances, or cases, are so numerous that they cannot all be named and classified into exhaustive lists, the learning task becomes one of being able (a) to define verbally the distinguishing features of a class; (b) to give examples of it, and (c) to recognize examples that do not belong to it. Most children think they know what a hotel is and can name a few examples. But do they know what it is about such a building that distinguishes it from other buildings of similar appearance? The answer is, of course, the kind of uses made of it. But similar uses are also made of homes and apartment buildings. The verbal formulation of what it is that distinguishes hotels from all other classes of buildings by giving examples that fulfill and do not fulfill, these specifications are the major tasks of conceptual learning. This learning consists of bringing the response of giving correct examples under the control of the name or a verbal definition.

Very little is known about the relations of visual and auditory stimuli in concept formation. The stimulus materials used in laboratory experiments are mostly visual. Stimuli that activate any sensory reception are classified and labeled. The labels are always verbal. The members of the categories are for the most part percepts. Concepts are constructed from percepts. If the task is to give an example of a concept, the stimulus is the name or the definition, and the response is verbal. But if the task is name the class to which an object belongs, the stimuli may be either the object, a picture of it, or its name.

Olsen (1963) compared the effectiveness of pictures, letters and numbers for the attainment of concepts by high school sophomores. The stimuli were presented on cards by adding one at a time. Each time one was added the subjects were required to identify and record the common element. If the correct element was identified on the appearance of the second stimulus the score was 10 points. It decreased as more stimuli were required to identify the common factor.

Two sets of pictures were used. One set was pictures of parts of a reciprocating machine, the other was pictures of levers. The letters were in groups of five with three in alphabetical order; and the numbers were in multiples of three.

For one group of subjects the order of presentation was from obvious to subtile (i.e. easy to hard), for another group the order was random; and for a third group it was from hardest to easiest. The results show that the order of presentation was much more important for the picture problems than for either the letter or number problems. This could be due to the fact that the number of problems were intrinsically easier than the picture problems. For the picture problems of reciprocating action the mean score of the "easy to hard" group was 7.8, for the "random" group 3.3, and for the "hard to easy" group 2.3.

It is difficult to evaluate the results of this experiment without seeing the dissertation on which the article reporting it was based. The author does report, however, that the selection of "obvious" and "subtile" examples of the pictorial concepts was based on rating by an independent sample of high school students, while instances of the letter and number concepts were selected by the experimenter.

3. The role of words and pictures in the acquisitions of responses of prehending and comprehending. Here, the learning task is that of grasping a new idea, understanding an explanation, or comprehending the

full meaning of a presentation. The notion of *getting something* from reading a book, hearing a lecture, or seeing a film, runs throughout educational literature. Students often complain about a presentation being *over their heads*, or failure to *get anything* new from it. To seize, grasp or latch onto is to *prehend*; to grasp all there is to be grasped is to *comprehend*.

What, now does one do to prehend and to comprehend? What kinds of responses are required, and how are they learned? Let us begin with the physical acts grasping and see if we can build up to higher mental processes. A monkey prehends the limb of a tree by wrapping its tail around it; and an infant prehends a pellet with its thumb and forefinger; adults pick up and manipulate objects with their fingers or by the use of instruments. But with what bodily organ do they "pick up" ideas? The obvious answer is, with their brains.

There are no doubt lines of connection between physical and mental prehension. There is a great deal of evidence, derived both from child psychology and the history of education, which clearly indicates lines of connection between object manipulation in early childhood and later manipulations of their surrogates. These lines of development are difficult to trace. There is involved, no doubt, a hierarchy of acquired abilities, beginning with the unlearned abilities of infants to manipulate objects. The line of development might stem from proprioceptive and autonomic stimuli produced by physical acts of prehending.

When a physical object is grasped, it may be reported as feeling hard or soft, large or small, round or oval or square, rough or smooth, pleasant or painful. Such verbal reports stem from feedbacks into the central nervous system of tactile, proprioceptive, and autonomic stimuli. These feedbacks provide several items of information--such as, the object is something that is round, hard, and smooth. It is the combination and integration of these items of information that constitute an "idea" of the object. The idea is comprehended when all relevant information is in and integrated.

The question now arises as to how one can grasp an idea of something without the benefit of first-hand information obtained from physical grasping and manipulation. The obvious answer is, it is done by grasping the meanings of the symbols and pictures that represent or stand for the idea. But what kinds of covert responses to surrogates correspond to the physical ones of grasping and manipulating? A good guess is that they are faint replicas of the physical responses. Replicas are muscular tensions, and other implicit responses, which produce autonomic and proprioceptive stimuli similar to those produced by physical manipulation. These covert replicas may be elicited by visual and verbal stimuli which by past experiences have become conditioned to them. By primary stimulus generalization, pictures of objects will elicit the same implicit muscular responses as seeing an actual object when it is out of reach. By the process of higher order conditioning, names of objects, verbal descriptions, and diagrams can gain control over the implicit responses of grasping. Thus, the implicit muscular responses and neural reactions could be the instruments by which ideas and explanations are grasped and understood.

A connection between responses required for the "mental" grasping of ideas and those involved in the acquisition of first-hand knowledge by manipulating and observing the physical environment, is an instance of a more general proposition. The proposition is that all vicarious learning--i.e., by being told or shown, stems from, and is based on, responses by which knowledge is acquired by first-hand experiences. These primary experiences are observations and manipulations. A great deal about the environment is learned by looking, listening, touching, tasting, sniffing and noting changes as they are sensed. The sensing of environmental stimuli is basic to perceptual learning which, in turn, is basic to learning by observations, which is further basic to all observational sciences such as astronomy.

This is not all. Humans can learn by observing the surrogates, or representatives, of the environment. An object, place, or event can be represented by a picture, or described in words. Such surrogates acquire meaning by the process of perceptual learning. It is only after such meanings have been acquired, is it possible to learn by observing surrogates.

The more firsthand knowledge a child has acquired about various features of his environment, the easier it is for him to acquire new knowledge from A-V presentations, provided he has also learned the relation between visual and verbal representatives and the feature of the environment for which they stand.

Valuable firsthand information is also gained by manipulating objects in the environment and noting what happens. This is illustrated by operant conditioning, and other forms of learning by experience. Experience is defined by John Dewey as "doing and undergoing"--acting on the environment and taking the consequences. This may be mere doing for its own sake, as illustrated by the play of children. It may be the kind of doings that are characteristic of all experimental science.

When objects, places, events and relations are represented by symbols, either linguistic or mathematical, such symbols can be manipulated independently of the objects or concepts that they represent. Some symbols denote objects and relations, other connote features abstracted from the environmental objects, events and relationships. This makes it possible to acquire a great deal of new knowledge without undergoing firsthand experiences,

This view of the learning process puts us in a better position to assess the relative merits of words and pictures in understanding explanations and in comprehending abstract relations and concepts.

Most of the responses here involved are, as previously indicated, the covert ones of prehending and comprehending. The question is what are the relative merits of words and pictures in motivating, cueing and reinforcing these responses.

The properties of words and pictures are discussed earlier in this paper and need not be repeated here. The problem is how to utilize them for the achievement of different tasks. The rules are different depending on the functions that words and pictures are intended to serve.

The construction of visuals that will aid students in prehending and comprehending principles and abstract ideas presents problems of finding visual representations with which students are familiar. Visual representations are more likely to elicit correct responses than verbal descriptions. Bar graphs are useful for visualizing relations between quantities of statistical data provided the student understands that the higher the bar the greater the amount. Visualization of principles and abstract relations that do not elicit the desired responses may elicit wrong responses, or leave the student in a state of confusion. For example, May and Lumsdaine (1958) found that an animated diagram of the movements of salt and water molecules through a semipermeable membrane failed to elicit the prehension of the point that the key to the explanation is the relative size of molecules in relation to the pores in the membrane. A general rule might be that the effectiveness of a visualization of an explanation, or of an abstract principle, depends mainly on the extent to which it contains a pattern of stimuli that will evoke the desired response.

A recent study by Vandermeer and Thorne (1964), on the use of filmstrips for teaching the relations between The Sun and Its Planets, illustrates the problem of finding an optimum combination of words and pictures for teaching astronomical facts and principles. The visuals were mainly photographs or drawings of the sun and the orbits of its planets. The verbals were printed captions. The subjects were students in grades 5 to 12. Knowledge of the contents of the filmstrip was tested with a large number of multiple choice items.

This filmstrip went through three revisions. Each was based on the test items that were incorrect on the preceding version. The effectiveness of each revision was tested by assigning groups at random to the originals or to the first revision and to the second revision. Items correct on the revised version were compared with those incorrect on the original. Also mean total scores were compared.

The revisions of the graphic and pictorial elements that seemed to improve learning rather consistently were (a) increasing the "iconicity" of a frame showing how the waxing moon would actually look from the earth rather than from other positions; (b) the multiplication of similar cues without increasing the content to be learned; (c) the additions of cue identifiers such as directional arrows. Other revisions which improved on some but not all parts, and which were better in some, but not all grade levels, were labels of objects, and grouping objects in ways to facilitate an estimate of their numbers. Plane views instead of perspective, and boundary lines around significant cues were also improvements.

Verbal captions were improved by underlining or capitalizing key words. The uses of repetition and redundancy for unfamiliar audio-visual materials tended to facilitate learning.

This study illustrates the difficulty of finding combinations of verbal and nonverbal stimuli that will gain control over all criterion response for all students. Another interesting point is that the greater the "iconicity," or realism of a visual, the greater is the probability that it will elicit a correct response. This is attributed to previous learning. Gropper (1963) reports an experiment in which a ball and ring were used to illustrate the principle that matter expands when heated. A cold metal ball is inserted in a ring and then heated. When heated the demonstrator could not pull it out of the ring. This visual demonstration of a principle was probably worth a good many words.

The relative merits of visuals and verbals for giving examples of abstract ideas and principles have also been investigated. In some instances a general principle may be understood from a simple statement.

In the case of Gropper's (1963) experiment, the simple statement that "all metals will expand when heated" may be sufficient provided the concepts of "metals," "expand" and "heat" have been previously formed. A more general principle that "all forms of matter expand when heated" may require examples showing how metals, wood, water and gases obey this law. At this point visual demonstrations of examples may aid in comprehending the full meaning of this principle. As Gropper (1963) points out it is not always possible to see what is happening when matter expands, but it is possible to see the effects, as in the ball and ring experiment. If the purpose is to go further and explain why matter expands when heated, visualization by animation showing the increases in speed of molecular action may be employed.

There are still other ways in which examples of abstract principles can be visualized. One is, as Gropper suggests, by analogy. Elective-motive forces are analogous to hydraulic systems. The activities of electrons, protons, and other "trons" in various kinds of atoms may be represented by mock-ups.

Part IV - Consolidating Responses

1. Nature of the Problem

The problem stems from the well-known fact that a great deal of the knowledge gained through any medium of communication is forgotten. Much of it is lost almost immediately. Some parts are retained longer; a few may become life-long possessions. Knowledge that is lost beyond recall is patently not available as an aid to further learning or for the solution of problems. Forgetting, on the other hand, may sometimes be a blessing.

The problem of immediate concern is to discover the conditions under which new facts, concepts and understandings, learned from one or two exposures to an A-V presentation, can be consolidated and fortified so that they will be retained and available for further learning and for other uses. There are grounds, both theoretical and experimental, for believing that more is learned from one exposure to most A-V presentations than is revealed by post-tests. One reason is that, even when the materials are correctly perceived and well understood and fully comprehended, they will exceed the span of immediate memory of most students.

In a typical experiment on memory span, a sequence of verbal material is presented and the subject is tested immediately on how much of it can be recalled. A review of the experimental literature on short-term memory by Postman (1964) indicates that there are many conditions that determine how much and what kinds of verbal materials can be recalled immediately after one presentation. In practically all of these experiments, the learning task was to reproduce the material verbatim. From these studies it may be safely inferred that the materials contained in an instructional film of average length far exceeds the reproductive memory span of all students. The problem of how much of the substance of a presentation learned from a single exposure can be retained has not been investigated. Briggs and Reed (1943) have, however, reported a curve of retention for substance materials.

The conditions under which programmed materials are learned are similar to those found in experiments on short-term memory. Variations in the size of the steps in programmed materials are similar to variations in lengths of sequences to be recalled after one exposure. In both cases a test is given immediately after a single presentation of each sequence. When A-V presentations are programmed, as was done by Gropper and Lumsdaine (1961), and much more extensively by Carpenter and Greenhill (1963), it was found that scores of immediate post-tests are higher than when the materials are presented in the conventional manner. These experiments indicate that when the material to be learned is presented in a series of sequences, each of which is within the memory spans of the subjects, more of it is retained. It may be that the same materials are learned just as well from conventional methods of presentations as they are from programmed methods, but are retained longer when programmed.

The shape of curves of forgetting provides further evidence in support of the proposition that more is learned from an A-V presentation than is revealed by post-tests administered immediately after showing. The typical curve drops sharply during the first few minutes after learning and gradually levels off. This shape has been found for memory of content or substance as well as for verbatim memory (see McCeogh and Irion, 1952, p. 358). The initial drop, however, is sharper for verbatim than for substance memory. (Briggs and Reed 1943)

In most experiments on learning from A-V presentations the post-test is given as soon after showing as feasible. The delay may vary from a few minutes to a full day. If the task is reproductive, as it is in memorizing lists of names, stanzas of poetry, or vocabulary of a foreign language, the loss during the first few minutes of delay may be very substantial. For substance memory the loss may be less during the first few minutes but still enough to indicate that more was learned than was retained.

An experiment demonstrating that there is a loss after a very short delay is reported by Smith (1965). Three versions of a filmstrip on the Earth's Satellite: The Moon, were prepared. In the first version each frame was followed immediately by one or more test items; in the second version the frames were organized into a number of logical sequences, and after each sequence of frames one or more test items were given; in the third, the whole strip was presented and followed by an 80-item test. These items were the same as were used for the first two versions. The entire test was administered again to all subjects after a delay of 20-25 days.

The subjects were 745 students in grade five to eight and in grade eleven. Intact classes were assigned at random to the three versions. Half of each of the three groups was given the correct answers to the test items immediately, the other half was told the correct answers on the following day. On the tests of immediate recall the differences between the mean score of the three groups were significant. The group who saw the "frames" version had the highest mean score, the "sequence" version next, and the "whole" version poorest. But when a similar comparison was made on the basis of the scores obtained on the delayed test, differences between groups were no longer significant. Furthermore, the half of each group that received knowledge of test results immediately had a significantly higher mean score than the half who received the information a day later. But, again on the test of delayed recall this difference was not significant.

The superiority of the "frames" method may be attributed to the fact that the material contained in each frame did not exceed the immediate memory span of most students. Because immediate memory span is one test of intelligence, it is not surprising that Smith found the more intelligent students receiving the highest scores.

2. Retention of Materials to be Reproduced Verbatim

The conditions on which verbatim retention depend have been investigated by a very large number of laboratory experiments extending as far back as the classical work of Ebbinghous On Memory published in 1885. From his basic studies on the learning and retention of nonsense syllables have sprung many hundreds of experiments on the learning and retention of many kinds of verbal materials. In most experiments, the learning task is rote memorizing and the criterion test is verbatim reproduction. The results of experiments on retention and forgetting, that were published prior to 1952, are summarized by McCeogh and Irion in The Psychology of Human Learning. More recent summaries are found in volumes by Ausubel (1963), Cofer (ed. 1961), Melton (ed. 1964) and Underwood and Shultz (1960). In addition to these books of reviews of the experimental literature on verbal learning, other reviews have appeared in the Annual Review of Psychology for the years

(1957) (1958) and (1965). Anyone interested in doing research on the problem of the retention and utilization of knowledge gained from A-V presentations will profit by perusing these reviews for relevant facts, principles and experimental methods.

The conditions on which the reproduction of materials learned from A-V presentations depend have not been specifically investigated. Some of the conditions, however, on which the retention of such materials depend are the same as the conditions on which the retention of meaningful verbal materials, when presented visually or aurally, have been found by experiments to depend.

One condition is that the more difficult the material is for a learner, the less of it will be remembered. Experiments contradict the popular belief that hard and slow learning makes remembering easy. Experiments indicate that the opposite is true. The easier the material is for the learner, and the faster it is learned, and the better it is retained. Difficulty in learning stems from three main sources. One is the lack of general mental ability to learn; another is the unfamiliarity with the materials; and a third is the amount of unlearning of previously acquired misconceptions and inaccurate information that may be required.

Materials that are relatively unfamiliar to a learner are difficult because of a lack of prerequisite relevant knowledge. The more a student knows about a subject the easier it is for him to learn more and the greater will be the gains from a single presentation. This point is illustrated by Lumsdaine's experiment where he found that students who had received previous instruction on the topic of osmosis acquired a greater proportion of new knowledge from the film Osmosis than students of comparable general abilities who had not received previous instruction.

Another source of difficulty in learning, and in retention, is proactive inhibition. This occurs when previously acquired responses inhibit, rather than facilitate, learning. When the responses to the relevant cues, required by the learning task, have previously been associated with irrelevant responses, the irrelevant ones must be unlearned or superseded by the relevant ones. This is illustrated best by the difficulty of learning a new keyboard on a typewriter, when a different keyboard has been previously learned. In learning from an instructional film proactive inhibition could be caused by requiring responses that are unacceptable to a learner. He may decline to believe some of the information that is conveyed because it is dissonant with some pet idea. An experiment by Sharp (1938) indicates that acceptable materials have a higher retention value than either neutral or unacceptable materials (see McCeogh and Irion, 1952, p. 389; also Hovland, Janis and Kelley (1953)), on Persuasibility.

The degree to which the material is learned is another variable on which retention depends. In laboratory experiments the degree of learning is measured by the number of times the material is presented, after it is learned, to the level where it can be recited without error. Further repetitions are called over-learning. Increasing the number of over-learnings will increase the length of time that the material is retained, up to a certain point. Over-learning is very similar to continued review. Some degree of over-learning may be accomplished by showing a film twice or three times, but it requires high level of motivation to overcome the effects of boredom. Over-learning facilitates retention partly because it reinforces the responses to the relevant cues and fortifies them against incorrect competing responses.

Practice is another condition on which retention depends. Practice is effective, especially under varying conditions, because more and more stimulus elements become conditioned to the required responses. The greater the number of stimulus elements that become conditioned to the responses, the greater is the probability that some of them will be present in the test situation. This point is illustrated by an experiment by Abernethy (1940). He found that when students took an examination in a room where the learning occurred, and were proctored by their instructor, they performed better than a control group who took the same examination in a different room proctored by a stranger. In rote learning, distributed practice has been found to be more effective than massed practice. Some experiments employing A-V presentations, reported in the previous paper, indicate that the effectiveness of spaced practice depends on the nature of the learning task.

One more condition favorable to retention may be mentioned. In experiments on rote verbal learning, it is found that learners usually invent and employ strategies of learning that aid recall. One strategy is to group the materials into categories that have a common associative bond. Another is to associate each item with a familiar name, place, number, or relationship between numbers. The telephone number 248-1959 can be remembered by noting that 4 is twice 2 and 8 is twice 4, and that 1959 is the number of a year.

All such devices facilitate recall because they provide links between the stimuli in the test situation and the correct responses. All mnemonic aids are associative links. In associative learning visual images often serve as useful mediators between verbal cues and correct verbal responses. The role of visual images as mediators is discussed earlier in this paper (the role of links in association learning, see Gagné, 1965).

A major cause of forgetting is retroactive inhibition. This phenomenon has been thoroughly investigated by laboratory experiments. The materials used are mainly lists of nonsense syllables, letter, digits, meaningful words, sentences and paragraphs. The conditions under which the ability to recall is interfered with by subsequent learning are fairly complex and need not be reviewed here. The extent to which the recall of facts and concepts learned from A-V presentations are inhibited by further learning that occurs prior to the time when a retention test is given is not known. We do know, however, that when an information test is given immediately after showing, the scores are usually higher than when the same test is given after a delay of a week or longer. Forgetting does, indeed, occur. But how much of it can be attributed to retroaction inhibition is not known. A related fact is that perceptual-motor skills acquired from A-V demonstrations are retained much better than verbal materials. Also conditioned responses persist over long periods of time if extinction trials are not given. In the previous paper instances were given of long-term memory of information gained from films.

3. The retention of concepts, ideas and explanations. There is some experimental evidence that the substance of connected verbal discourse is retained better than the words in which it is delivered. Katona (1940) has published a considerable amount of experimental data which indicates that when the learning task requires that the materials be understood, or that a principle be discovered, the basic ideas are retained for considerable periods of time. Katona's main contention is that when the learner is required to discover a principle or explanation, it is better retained than when it is communicated. Although discovery

may facilitate retention, it is probably not an essential condition.

A more basic condition is the manner in which the learner restructures the materials during learning. A number of experiments have been reported on comparisons between rote and logical memorizing. When subjects are instructed to look for meaningful relations and to organize them into logical sequences, or into categories, learning is much more rapid, and retention is better, than when subjects are not so instructed (Cofer and Segal 1959).

Another factor on which retention depends is the conditions of recall. In free recall no limitation is placed on the order in which the memorized materials may be reproduced. This condition stands somewhere between ordered reproduction and "substance" recall. Conditions of learning and of testing on which substance recall depends have not been investigated beyond the pioneering experiments of Katona. Some of the organizational characteristics of free recall, reported by Cofer (1965) may also apply to substance recall.

A basic connection between verbatim, free, and substance recall is that in all forms of verbal learning experimental subjects do, in fact, reorganize the materials into clusters or categories according to conceptual schemes. Such schemes are now considered products of previous learning and not innate categories of the mind. Because the categories into which knowledge is organized are learned, they are never exactly the same for all individuals. There are, however, similarities especially among persons who speak the same language and whose habits of thinking are shaped by the same culture. (see Bonsfield 1953)

Experiments on verbal learning indicate that when the material is presented in an organized manner, it is learned faster and retained longer than when the items are presented at random. There are, however, individual differences in the rates of learning the organized presentation due, presumably and in some parts at least, to differences in previously learned conceptual schemes. Outlines of courses taught in high schools and colleges sold in book stores to students may be helpful, but not as much as outlines made by each individual in preparation for examinations. The problem of how best to organize and sequence A-V presentations is the topic of another working paper.

4. Sense Organs Stimulated as a Condition of Retention

References have been made earlier in this paper to experimental evidence which points to the general conclusion that audio-visual presentations result in better learning, as measured by tests of immediate recall, than either visual or auditory presentations. In most of the experiments in which significant differences have been found between auditory and audio-visual presentations of the same content, delayed tests of recall were not administered. There are instances, however, in the experimental literature where significant differences were found between mean scores of experimental and control groups on immediate recall, but were not significant on tests of delayed recall. Whether material learned audio-visually is retained better than when it is learned either aurally or visually is not known.

Most of the laboratory studies in which sensory channels of reception have been compared indicate that lists of words are learned fastest when each item is seen, heard, and articulated. Three sensory channels are utilized - visual, auditory and kinaesthetic. There are, however, individual differences in sensory dominance. In popular parlance it is called "eye-mindedness" and "ear-mindedness." An interesting by-product of Asher's experiment on learning Spanish vocabulary was that 18 out of 34 college students were visually, and 14 were aurally dominant. The visually dominant students made fewer mean errors in learning vocabulary when the items were presented visually, than when they were presented aurally. Likewise aurally dominant students made fewer mean errors when the items were presented aurally than when presented visually. These results are merely suggestive because of the small number of cases in each of the groups. Individual differences in abilities to use different sensory cues do, in fact, exist as demonstrated by Carlson and Carr (1938). These differences have effects on the rate of learning of materials visually and aurally. Their effects on retention, however, may be negligible for the reason that the brain is so organized that information received through a less dominant channel may be retained through a more dominant one.

Information received aurally may be visualized. If so, the visualization may be better retained. Also information received by ear may be rehearsed subvocally, in which case kinaesthetic stimuli may mediate recall. When material is presented visually to an aurally dominant student, he may think of how it would sound when spoken. It is precisely this capacity for translating from one sensory modality to another that makes it almost impossible to classify students according to sensory dominance. The process is not unlike that of inventing strategies of learning which mediate recall.

Visually dominant students may indeed learn and remember better visually than aurally because they do not need to go through the process of translating it into another modality. For the same reason, aurally dominant students may learn and remember spoken materials better than when they are presented visually. One of the reasons why audio-visual presentations are superior to either visual or auditory ones is that translations are ready made for both the visually and aurally dominant students.

Part V - Summary and Outlook

The problem of discovering the advantages and disadvantages of visual and auditory stimuli for motivating, cueing, and reinforcing the responses required by different learning tasks, is indeed formidable. The approach suggested in this paper is largely theoretical. Relevant experiments are found mostly in the literature on verbal learning. This literature, however, is largely on problems of memorizing. Experiments relevant to the problem of learning the substance of A-V presentations are few and far between. Scattered through the literature are experiments in which A-V materials are used. In these, a few bits and pieces of information are found that are relevant to the problem of picture-word relationships. Because of this lack of relevant experimental data, the best that can be done now is to suggest and illustrate a framework within which further analyses and experiments may be conducted.

The analysis suggested in this paper takes into account four interrelated sets of variables. Briefly designated as stimulus, response, task, and audience. The sequence of responses that is required to learn from an A-V presentation is specified, to a large degree, by the nature of the learning task. These responses are motivated, cued, and reinforced by stimulus variables. The ability to make the required responses to the stimuli contained in the presentation is determined by audience variables. Among these are general intelligence, special aptitudes, and previously acquired knowledge that is relevant to the learning task.

This analysis shows the complexity of the problem of assessing the relative merits of visual, auditory and audio-visual stimuli for performing the functions of motivating, cueing, and reinforcing the kinds of responses that are specified by different learning tasks. In order to fulfill the conditions specified by different tasks, it may be necessary to introduce into the presentation stimuli that perform only one, or perhaps two, of the three functions. But when this is done, such stimuli may have undesirable side effects, as was noted in the previous paper. Some stimuli may be very effective for motivating and cueing the responses of attention, and at the same time be irrelevant to the learning tasks, and hence distract attention from the relevant cues.

The search for experiments that throw light on the problem of audio-visual relationships in learning from films and ETV programs leaves one with the impression that there is a vast no-man's land between the large and rapidly growing number of laboratory experiments on verbal learning, on the one side, and the increasing number of experiments on teaching with A-V materials on the other. This territory has been only partially explored. The theoretical analysis suggested in this paper is not unlike a map of the boundaries and some of the outstanding features of an unexplored geographic domain. The immediate need is for more explozatory studies that will help bridge the gap between the abundance of laboratory experiments on verbal learning, perceptual learning, and concept formation on the one hand, and learning from complex A-V presentations, on the other. Examples of such research include, Lumsdaine's study of picture-word relations in paired-associate learning, Kale and Grosslight's study of learning Russian vocabulary, and Asher's study of learning Spanish vocabulary.

An experimental program may be developed by approaching the problem of learning from A-V presentations from the standpoint of individual differences. What variables are correlated with individual differences in amount of knowledge gained from a single exposure to an A-V presentation, in addition to general intelligence and special aptitudes? Among the ones suggested in this paper which can be measured with appropriate instruments, are: (a) level of achievement motivation, (b) interest in the subject matter, (c) attention to relevant cues as measured by proportions of informations gained that were irrelevant to the learning task, (d) the extent to which the intended meanings of the words and pictures were understood, (e) the degree to which the nature of the learning task was perceived, (f) the amounts of previously acquired knowledge relevant to the learning task, and (g) sensory dominance.

This list of measurable variables on which learning from A-V presentations depends could be extended. It is sufficient to illustrate that the correlational method may be used with profit to explore the interrelation of a complex system of variables. Such an exploration should be useful for designing experiments in which important variables are systematically investigated.[1]

Another pre-experimental line of investigation could be conducted by interviewing selected students after a film has been shown and the post-test administered. An interview schedule could be designed in a manner that would reveal the failures and successes to make the responses required for learning at each step in the learning process--from attention to recollection. The schedule could include questions designed to reveal the extents to which the required responses were cued by visual, auditory, and audio-visual stimuli.

The interview schedule should be in two parts--general and ideosyncratic. The questions in the ideosyncratic part would be taken from the incorrect items on the post-test of each individual. The purpose would be to ascertain why such items were missed. Was it due to a lapse of attention, failure to perceive the correct meanings of the words and pictures, failure to form the correct associations or to understand the explanations, or for other reasons?

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[1] Wittenborn (1943) using factor analysis on the correlations between two tests, verbal and numerical ability, discovered a new factor not previously recognized. It was called an attention factor.

Further studies of the roles of words and pictures, for motivating, cueing, and reinforcing the sequences of response that are required by different learning tasks may be conducted either in classrooms or in laboratories. The data required by correlational and interview methods will come mainly from classrooms. But classrooms are not as well suited as laboratories for carefully controlled experimental studies. More laboratory experiments are needed on problems that are relevant to the process by which knowledge is communicated by A-V presentations. Many of the numerous laboratory studies on verbal learning are relevant to the verbal contents of films, but few are relevant to the visual contents. To cite a single example, King and Cofer (1960) found that the number of adjectives modifying nouns had an effect on the amount of the content of a story that could be recalled after two presentations. The fewer the adjectives the more of the content was recalled.

In addition to a long-term program of research employing correlations, interview, and experimental methods, are a number of specific problems that may be investigated in shorter periods of time. Some have been mentioned in this paper. They are summarized here for convenience of reference.

1. The relative merits of words and pictures for attracting and holding attention should be further investigated. The experiment by Ketcham and Heath suggests an hypothesis that pictures containing no additional information, but having a measure of relevance to the verbal content without distracting attention from it, will facilitate learning. Visuals that are irrelevant but have no attention attracting properties were found to have no effect on learning; but irrelevant pictures appear to have an adverse effect. Because the visuals employed in the film used by Ketcham and Heath presumably contained no additional information, their effects on post-test scores can be attributed to their effects on attention.

A related experiment by Barlow and Westley (1959) shows that the same content is learned better when presented by TV than by radio. But in order for the content to be the same, the visuals must present no additional information. A question arises as to whether or not it is possible to find visuals that are relevant to the verbals which contain no information whatsoever. How can visuals be relevant to verbals and at the same time contain no information?

2. There is need for more analytical studies of the roles of visuals and verbals (a) when the verbal content carries the main load

of the information, and the visuals are employed to illustrate and reinforce the meanings of the verbals, and (b) when the situation is reversed, and the visuals carry the main load of information and the verbals are employed to explain the meanings of the visuals. Experiments by Allen (1952), and Gladstone (1958) on the simplifications of narrations indicate that simplifications are effective when the narration contains the major part of the information, but have little effect on learning when a major part is contained in the visuals.

3. Experiments reported in the paper on Enhancements and Simplifications suggest that prefilm verbal instructions and other verbal procedures are more effective for directing and sustaining attention than built-in visual devices and that visual devices are more effective for cue identification. This proposition needs further investigation before it can safely be recommended to producers of audio-visual materials. If it is confirmed by further studies, the question would still remain as to why verbal stimuli should be more effective than visuals for motivating attention, and why visuals should be more effective for discriminating relevant from irrelevant cues.

4. A related problem is that of the relative merits of words and pictures for specifying and clarifying the nature of the learning task. For example, the task of learning a perceptual-motor skill is obviously specified more clearly and adequately by a visual demonstration

than by a verbal communication. A verbal pre-test should also serve notice on the students that it contains items that they are expected to learn from the presentation. In this connection, mention may be made of the use of sample items given on intelligence and achievement tests to indicate clearly to students the kinds of responses they are expected to make to the test items. The introduction to a film could be constructed so as to make quite clear to students what the learning task is.

5. In the section on perceptual responses and perceptual learning, it was noted that misunderstanding of the intended meanings of spoken words and of the visuals could result in failure to learn. The extent to which misperceptions result in failures to learn could be determined by preparing a pre-test composed of key words and sentences from the narration and of key items in the visuals. Each multiple choice item would require that the choice containing the correct meaning be checked. These items could be matched to items on the post-test that measure amount learned. A high positive correlation between individual scores on the two tests would be expected.

6. The experiments by Lumsdaine (1958) and Bern (1958) on picture-word relationships in paired-associate learning suggest that the optimal relationship is a function of the criterion test. If the test is to name the correct associate when the stimulus word (or picture) is presented, the picture-word relation is the best, and the word-picture

is the poorest, (Lumsdaine). But if the test is to choose which of three or four response items is the correct one, then the picture-picture relationship is best (Bern). Several questions are left unanswered. What other differences between these two experiments could account for differences in results? Why should different criterion tests yield different results?

7. In two or three places in this paper, reference is made to the role of mediating links that connect stimulus and response terms. Such links have the properties of both responses and stimuli. The stimulus term elicits a mediator which elicits the desired response. The links may be visual images, silent verbalizations, or proprioceptive stimuli. The question is: what are the relative merits of words and pictures for providing associate links between stimuli and the responses required by different kinds of learning tasks?

8. A basic problem in constructing A-V presentations is how best to visualize abstract ideas, principles and explanations. Here the role of the visuals is to clarify the meaning of the narration. If the visuals are diagrams or models that are familiar to the learner, they may have meanings that are contrary to those intended by the narration. If they are strange, or ambiguous, they may distract attention from the narration. The problem is to construct visuals which by previous learning have meanings similar to those which the spoken words are intended

to convey. It is a problem of linkage. The links are meanings common to the visuals and the narration.

9. The theory advanced in this paper that the covert responses involved in grasping a new idea are neural replicas of physical response of grasping objects may be tested by the use of a program analyzer. Instead of pressing a button or turning the knob of a dial to indicate liking or learning, the subject would be provided with a soft and hollow rubber ball to hold in his hand during the presentation. No instructions would be given except some plausible excuse that would not reveal the true purpose. An air hose attached to the ball would activate a stylus for recording changes in pressure. The high and low points on the graphic record could be matched to test items that measure how well each new idea or explanation was grasped. The rubber ball technique has been used in experiments for measuring extra effort that is exerted to overcome distraction from a learning task. (See Block 1936)

10. In a surprisingly large number of experiments on learning from A-V presentations, significant differences between experimental and control groups on tests of immediate recall disappear on tests of delayed recall. In a very few experiments the reverse is true. Could it be that the group who gained most lost a greater percentage of the amounts gained than the group who gained least? Or did the group that gained least improve its mean score on the test of delayed recall due

to the phenomenon of reminiscence? Here is a problem of both practical and theoretical importance.

11. What are the relative merits of words and pictures as stimuli for eliciting responses of reinforcement? Such responses have been variously designated as confirmatory (Thorndike) or relaxing (Dollard and Miller). Groper (1963) has made a good case in favor of pictures. He points out that in the routines of daily life such as dressing, tying shoe laces, and shaving we are constantly looking for evidence that these acts have been successfully performed. Looking for confirmation is a much better established habit than listening for it. The Bible tells us that the Great Creator looked upon his handiwork and saw that it was good. There are, of course, many instances in which auditory feedback is reinforcing. A classical example is Thorndike's experiment where the spoken word "right" was the reinforcer. The problem is to discover the relative merits of visual and auditory stimuli for reinforcing responses required by learning tasks.

12. A problem basic to understanding picture-word relationships in learning from A-V presentations is that of sensory dominance. Asher found evidence that visually dominant students learned Spanish vocabulary with fewer errors when the stimuli words were presented visually and the response words written, than when the stimuli were presented aurally and the response words pronounced. The opposite was true of aurally

dominant students. But on tests of retention there were no significant differences. Thus, it appears that sensory dominance influences learning but has little or no effect on retention. Why so? One hypothesis is that, regardless of the channel through which verbal materials are learned, they are retained by transferring them to a sensory dominant channel.

Here is a problem of considerable importance that requires further study. More laboratory experiments are needed to explore the relation between sensory dominance, learning, and retention. A classroom study is suggested in which students would first be tested for visual and aural dominance, and divided accordingly into two groups. Then select, or construct, two films as nearly alike as possible in content. In one film the narration would carry the heavier load of information; in the other the heavier load would be carried by the visuals. From the sensory dominance hypothesis, it would be predicted the visually dominants will learn more from the visual, than from the aural film; but the reverse will be true of the aurally dominants. It is further predicted that, on tests of delayed recall, these differences will disappear.

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